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REPORTS

ON THE

VIENNA UNIVERSAL EXHIBITION

OF

80229

1873.

PART III.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE E. EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1874.

C.—1072.-II.] *Price* 6*s.* 3*d.*

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INFLUENCE OF INTERNATIONAL EXHIBITIONS.

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ON THE INFLUENCE OF INTERNATIONAL EXHIBITIONS AS RECORDS OF ART INDUSTRY.—By Professor T. C. ARCHER, F.R.S.E., F.S.A.S., President of the Royal Scottish Society of Arts, Director of the Museum of Science and Art, Edinburgh.

Industrial Exhibitions, and especially International ones, must now be looked upon as established institutions amongst civilised nations. They may undergo important changes, but they will go on, for with all their shortcomings and defects they have worked great good, not merely by increasing the material wealth of the world, but especially in diffusing principles of good taste amongst the masses in all countries where they have been held. It is not an extravagant assertion to make, that the two great Exhibitions of 1851 and 1862, and the admirable local Exhibition at Manchester in 1857, have done more to elevate the national tastes in Great Britain than all the school and book training put together. But it is not intended to assert that this enormous good has been attained by the simple fact that hundreds of thousands of people visited those Exhibitions, and saw and appreciated the treasures displayed there; on the contrary, it is most likely that had no other influence been at work than that which drew the crowds to our Exhibitions, it would hardly have extended beyond the short periods when they were in progress. But these displays produced an upwaking of latent tastes in the people, and what was still more effective, the emulative spirit of those who catered for the public was stimulated, and a race was commenced which will not soon terminate.

Already the extreme ugliness which marked the attempts at decoration on our pottery and porcelain, glass, metal-work, &c., at the commencement of the second quarter of the present century, and which called forth the pity, if not the contempt, of our neighbours, has passed away; everywhere may be noticed the dawnings of genuine taste, and in numerous instances a progress which places us on a level with foreign competitors. This is due to the fact that the Exhibitions have proved to be great schools in which object-lessons on the grandest scale have been taught to millions of people. The love of beauty is innate, and even individuals in whom it has never before been aroused, rarely fail to see the difference between similar objects, which have been well or ill decorated; therefore such persons in our exhibitions learn

to appreciate the good, both in industrial and decorative art, and demand improvement from those who administer to their wants. These again see in the excellencies, or defects, of their fellow-exhibitors, their own strong and weak points, and are stimulated to still further improve the former, and to cure the latter. If such are the effects of the International and local Exhibitions, it is clear that there should be some schools in which artists and manufacturers can take lessons, for however capable they may be of self-improvement, the progress is too slow for the demand. It follows then that the repositories of good workmanship and the best designs should be within their reach, not that they may assist them to copy, but that they may study, and learn the excellencies of those whose works have earned them the honour of being so preserved, and without altering the flight of their own genius, render it brighter by light reflected from the productions of their predecessors. Under the beautiful skies of Greece and Italy, objects of beauty could be placed in the open air, and all could see them, hence museums were not necessary, but what Nature kindly preserved, social revolutions threw down, and too often destroyed. The dry soil has been our friend, and the fashion of burying beautiful ornamental works with their dead has also preserved vast numbers, which the instincts of modern civilisation have taught us to collect and preserve in museums, which thus become repositories of the precious æsthetical culture of past ages, and the training schools for future ones. The idea of preserving such treasures in museums has undergone a great change since 1851, and as it was then perceived by those who so wisely managed that great affair, that thousands of the best ideas which there had development, had been derived from the study of museum objects of a class which were not then in much favour in museums, the time had come for paying more attention to decorative art apart from mere antiquity, or its historic teachings, and also that the works of the handicraftsmen, if worthy, should be used to stimulate and teach others. The South Kensington Museum therefore sprung into existence, and when this transition period has passed and its jealousies and opposition, have, with its errors of management passed into oblivion, Great Britain will be as proud of it as of any institution she ever possessed. It is a grand Artesian well, which has pierced through the thick strata of ignorance, and dullness to Art, and although from the newness of the borings, the water has run somewhat muddy, it will ere long, unless mischievously choked, pour a clear and pure flood of refinement and taste over the

length and breadth of the land. With a Prime Minister who has a passionate love for the beautiful in Art, whether he holds the purse-strings or not, we may be sure, if angry passions will drop into repose, and a fair allowance be made for the other exigencies of the state, that the new era of Art-progress will receive fair encouragement, and will produce rich fruit. And should we ever hold another Great Exhibition, which is by no means unlikely, for the decennial evidently pleases the world better than the annual, there will be a progress shown in all branches of Art and manufactures which will give ample cause for national pride and exultation.

The Exhibition proper being thus a diffuser of artistic and industrial knowledge on a grand scale, museums should become the repositories to a large extent of those objects which can be made the means of extending such lessons, and thus aid the artizans upon whose skill and industry future Exhibitions have to depend.

In no country is this use of museums more striking than in Great Britain, for the natural result of our commercial prosperity is to create numerous purchasers who eagerly explore exhibitions in search of objects on which they expend large sums, and withdraw them from the public to decorate their own dwellings; without museums therefore Art-students would have very slender chances of studying from examples, and this would of course cause a dearth of novelty in designs, which would soon deteriorate the public taste and render exhibitions less valuable. These remarks apply most especially to that now numerous class of museums at home and abroad, which have actually sprung out of the International Exhibitions, chief amongst which and also the first in point of time, is, as before mentioned, that of South Kensington, which started into existence immediately after the Great Exhibition of 1851, and was at first stocked chiefly with its acquisitions therefrom. Fortunately from the very first that grand establishment has been directed with great energy and consummate skill, and its influence on every Exhibition held in Europe since its commencement has been very striking. Two features in the management of South Kensington have been especially beneficial, viz., the Loan collection and the system of collecting reproductions of such art-objects as could not be otherwise obtained. By the first of these, private collectors are induced to lend freely for the public benefit what would otherwise be producing only a comparatively small amount of good, the art-student is presented with an endless series of the finest examples,

and the public taste is elevated by the display of collections so rare and valuable that even the public purse would be unable to procure them for the nation. The system of procuring reproductions of original and unique objects gives a splendid opportunity for stocking the art-schools with such examples as could only otherwise be studied in distant countries, at great expense of time and money, neither of which as a rule are abundantly at the disposal of those who are real workers. In Great Britain, besides South Kensington, and Bethnal Green, the Government has also established museums for similar purposes in Edinburgh, "The Museum of Science "and Art," and in Dublin; and the municipal authorities in numerous centres are actively working in the same direction.

France has long made her museums so thoroughly practical that no necessity has been caused for a change by the institution of exhibitions; her students are richly supplied with every branch of art, and technical examples, in convenient museums where every available facility for study is secured for them, and well they know how to use them. In the wealth of beautiful designs which were countless in their great International Exhibition of 1867, those who were well acquainted with the collections of the Louvre, the Hôtel-Cluny, the Sèvres, and other museums, had no difficulty in recognising the teachings of those splendid schools of art; and doubtless many of the best features of the mechanical and other forms of technical ingenuity had been derived from that excellent institution, the Conservatoire des Arts et Metiers.

Italy followed the example of Great Britain, and in 1862 originated what we may call an Exhibition Museum in Turin, under the able direction of the then Minister of Commerce, Commendatore Minghetti, and by the activity and talents of the first appointed Director, Chevalier Jervis, it rapidly obtained a considerable importance. It has, however, had to contend with the various difficulties which were certain to arise in such institutions by the removal of the seat of government to Florence, and to Rome.

Russia also felt the advantages which such museums give to the public, and the Industrial Museum, or Museum of Rural Economy, first under the direction of M. Tcherniaeff, and now of M. Solsky bears evident marks of having been formed upon English models. A large portion of it is devoted to the illustration of food, exactly upon the plan of the Food Museum of South Kensington, to which is added also the food of domestic animals, whilst the application of vegetable products, such as trees, their roots, seeds, bark, &c., are shown

as in the Kew Museum. The animal products are also arranged on the South Kensington plan, and there is in addition a department for mechanical and engineering appliances for working the land, and for draining and other farming operations. This Museum has been founded since the Exhibition of 1862. The whole of the departments are on a grand scale, and the lessons taken from this country have been well carried out and greatly amplified. The building itself was formerly a riding school for the Imperial palace, and is one vast hall, 420 feet in length, 105 in width, and 35 in height, without a single pillar to support its plastered ceiling. It is under the government of the Ministry of Crown Domains, and is intended to diffuse a knowledge of the sciences connected with the production and utilisation of the substances required for food, and with this view there are workshops and artizans connected with the establishment, who produce many of the smaller kinds of useful implements, &c., which are sold to *bonâ fide* farmers at a profit of five per cent. only. Free lectures are given in this Museum at certain periods, and readers of agricultural works are allowed the use of the library for that purpose, or rather a library is specially arranged for them on the tables, on which all the books of any value in the Russian language are laid.

A very considerable proportion of the specimens in this museum are purchases made at the English and French Exhibitions. In addition to this a museum of a more general character was commenced last year, in which the ornamental and industrial arts will be represented after the manner of our Industrial Museums. Many valuable purchases were made for it at the Vienna Exhibition this year. In Moscow last year (1872) a very extensive general International Exhibition was held with the object of establishing by its aid a Polytechnic Museum.

Moscow also has a small but admirably organised Art Museum, with schools attached, which, under the able and energetic administration of M. Victor de Boutovsky, has done good service not only to the cause of Sclavonic Art, but also to that of International Exhibitions generally. Few who studied the Paris Exhibition in 1867 will have forgotten the extensive series of reproductions in stucco, coloured drawings, and designs, besides numerous antique examples, contributed by the Moscow Art School to the section devoted to the history of labour; whilst in the cases of the exhibitors, especially those of Sazikoff, Sapojnikoff, and others who exhibited goldsmiths' work, textiles, and lace in the antique styles, ample evidence was afforded of the large extent to which

the rich Treasury of the Kremlin and the other magnificent museums for Art Treasures in Moscow and Saint Petersburgh had been studied in order to furnish beautiful designs for the modern Exhibition. The same remark applies to the Vienna Exhibition of the present year. Whether we take the works in precious metals, in porcelain, in pottery, or in glass, we shall find that all the best designs by the chief exhibitors are the results of studying those rich stores of Art which the Russian Emperors have, in spite of all troubles at home or abroad, gone on collecting and preserving in their palaces, which are now museums available to all who require to use them. We even notice with some regret that this industrious study of museums has been carried so far as to deteriorate their own beautiful natural Art by mixing with it ideas from other and not harmonious national styles of Art derived from specimens bought in the Paris and London Exhibitions.

It is intended that the new institution in Vienna (the Athenée) shall also be a great Industrial Museum, and receive the vast contributions which have been made to it from the Exhibition. Vienna had already established a magnificent Museum upon the South Kensington model. This latter, "The Imperial-Royal Museum for Art and Industry," is very rich in specimens obtained from previous Exhibitions, and Baron Schwarz stated in a public speech that its British specimens purchased in the London Exhibitions of 1851 and 1862 had proved of great importance and value to the art-students who used it. A similar and extensive one has been established at Pesth, and is said to be working great good by improving the manufactures of Hungary.

Portugal is making great efforts in the same direction, and Baron Wildik, resident Consul for Portugal at Newcastle, has laboured assiduously for the last two or three years in this country to procure specimens for the Industrial Museum established at Lisbon under the direction of Cav. Fradesco, whose enthusiasm in behalf of his Museum cannot but be most beneficial. Germany, Belgium, Holland, and Switzerland have for a long time past known the true value of museums, and especially those devoted to the industrial arts; hence few towns in those countries are without a good Polytechnic Museum in which their artizans gain a knowledge of art and the processes of manufactures. They have benefitted largely by acquisitions from Exhibitions, but they have not sprung out of them. The value placed upon such collections in Germany can be somewhat demonstrated by the translation of some notes on the collections in the Royal

Würtemburg Museum, which will be found in Appendix A., whilst the still more important one of Munich is fully described in a letter from its director, Dr. J. H. von Hefner Alteneck (Appendix B.).

In the question really before us, "What benefits do "exhibitions gain from museums?" the best illustrations can doubtless be derived from the examples produced by our own country; that is to say, as far as our own impressions are concerned. Well then, let any one refer to the Inventory of Art Objects acquired for the South Kensington Museum in 1851, and he will see that a multitude of examples was accumulated which had their effect on our art-schools, and led to a great improvement in similar objects in the Exhibition of 1862, not suddenly, but through all the intervening years. At the period from which we started, our Ceramic Art had not attained even a respectable position. An abundance of similar illustrations of the effect of museum studies on our art-industries could also be cited from the Exhibition of Paris in 1867. This year, however, in the Vienna Exhibition, it is so striking that it is impossible not to be impressed with it. Take for instance, the magnificent collections of our potters and glass workers, and although there were no actual copies of museum objects, except in a few special cases, such as the exact reproductions by Messrs. Mintons of the Henri II. ware, yet the effect of art-training in the schools attached to the South Kensington Museum was most remarkable. So too in metal work, in the designs on textile fabrics of all kinds, and very especially so in goldsmiths' work and jewellery, whilst it also made itself manifest in every variety of useful article upon which taste in design could be shown. It will always be a matter of deep regret that so little was done to secure for the museums of this country from the rich abundance of beautiful objects which could have been obtained in every department of the Vienna Exhibition. No nation could have reaped greater good from purchases judiciously made than we could, and yet nothing comparatively was spent. Messrs. Elkington's magnificent work, "The Poetry and Music Vase," the Worcester porcelain decorated by "Bott," and several of the splendid productions of Mintons and Copeland, were of such a character as to make them of national importance as museum specimens, and to lose which will be a misfortune to the nation. Happily, there is in these firms a spirit of patriotism as well as of progress in art, and it is well known that for some of their finest things they refused foreign offers, preferring to keep them on their hands, rather than

let them leave this country. Doubtful as this may appear, it is nevertheless actually the fact. The museum authorities of Austria, Prussia, Russia, France, Bavaria, Würtemburg, and the United States of America all bought more largely of Art objects in the Vienna Exhibition than we did, and no Exhibition has yet been held in which so many advantages were offered to the purchasers of museum specimens, for it was richer than any previous one, and seemed to contain so much novelty of design, that it will be looked back to as an epoch in the modern Renaissance now in progress.

The keen appreciation of this feeling amongst the continental collectors was particularly noticeable, for before the Exhibition had been opened a week, there was hardly an exhibitor of art industry from one end of the vast building to the other, who had not got one, or more of his choicest objects ticketed as bought by the director of some museum. Ten thousand pounds would have been a small sum for Great Britain, but if well spent would have been a most profitable investment; several continental Governments spent more than a fourth of that sum, but hardly a thousand was spent by us. It is true our museums are now getting very rich, but many of the continental ones are quite as much so in such objects as are conducive to the real study of art, and certainly we have yet very much to do before we have a complete classified Art Museum, capable of giving the fullest information, and instruction to the student in merely industrial Art. It is to be hoped that our shortcomings in obtaining good examples from Vienna may not throw us back in the next Great Exhibition, wherever that may be, for these Exhibitions are bound to become points of observation on the great race-course of human progress, where the contest is now so keen that no nation can afford to throw away the slightest advantage. What we have hitherto done in this respect has been of vast service, and we must hope that although we shall now have to pay higher prices for them, we may still obtain some of the best examples for our national Museums and Art Schools.

By the admirable foresight and excellent arrangements of the Secretary to Her Majesty's Royal Commission, Mr. Philip Cunliffe Owen, abundant and exact information respecting the acquisitions of the Museums of various countries has been obtained and will be found embodied in the following appendices which will prove of great value to those engaged in the formation, or superintendence of public Museums.

APPENDIX A.

NOTES on the COLLECTIONS of the Royal Württemburg Central Institute for Trade and Commerce.

1. SAMPLE STORE of INDUSTRIAL PRODUCTS.

The sample-store owes its existence mainly to the attention which the Central Institute had to devote to trade and commerce at foreign Industrial Exhibitions. Although they set their technical writers to prepare the most exhaustive reports, which they spared no pains in circulating among the traders of the country, yet the influence that they were enabled to exercise by this means upon the national manufacturing centres was but small.

Quite a different result would, on the contrary, be produced if the improved foreign productions were introduced bodily under the eyes of the traders. This was evident at once when a quantity of exemplary work was brought from the French exhibition that took place in Paris in 1849, and set out for public inspection in the (then very contracted) locality of the Central Institute.

The interest that it excited exceeded all anticipations. His Majesty the now ruling King Carl, at that time Crown Prince, and his Royal Consort; and a few days later his late Majesty King William, visited this exhibition, and at once took under their especial protection the continuous extention of the collection of samples already initiated. The exhibition held at Leipzig in 1850 gave a further opportunity for promoting this extension. But before all else, the necessary space had to be provided; and the Central Institute succeeded in getting, not only their necessary offices, but also some rooms for a collection of trade samples, in the Battalion Barrack, which was at that time universally considered to be architecturally unsafe, and was therefore abandoned by the military authorities.

After this, when the First Universal Exhibition of Industry was held at London, in 1851, the Technical Councillor of the Central Institute, being on the spot in the capacity of Commissioner for Württemburg and member of the jury for the Zollverein, was empowered to make a series of purchases of the best goods illustrating every branch of Württemburg industry. This rich store was then made to supply especially the smaller manufacturing centres with improved and perfected tools and material, and further to set before the eyes of the trading public in general the precision, good taste, and solidity of foreign manufactures.

A little collection of sample goods in bone manufacture and basket weaving, made by Herr Moriz Mohl in 1843, on a trading journey through France, and useful for the last-mentioned object, was also added to the collections, and is an ornament of them to this day.

Greatly as the London purchase surpassed in quantity and value the previously collected objects, the energy with which, from above and below, a further development of the new institution was promoted was as great. Especial favour was found for the collections, initiated with the London purchases, of technical and decorative designs and means of instruction of every kind. A rich collection of instructive plaster casts was added to these for teaching drawing, and a school opened daily for advanced students of drawing, the directors of which were required to give special attention to the production of designs; to this has been joined very recently a workshop and central depository for the production and circulation of plaster casts for the drawing schools, which has published its own illustrated priced catalogue.

The Institute was recognised in foreign countries and numerously visited, not alone by those who had the intention, or were charged with the duty of creating similar institutes at their homes, but it was assisted also by many valuable institutions founded by manufacturers, who at the same time promoting their own interests and a good cause by sending in samples of their productions to this much visited permanent exhibition of wares, occupied a permanent or temporary place in the Institute.

The institute formed in the former dormitories of a squadron of cavalry became much too small, after the Industrial Exhibitions of Munich in 1854, and of Paris in 1855, had sent their contributions, to receive the collections which were industriously made in other places besides; happily, however, there remained at disposal, though it was a little dingy and decayed by mildew of the walls, the stables that had been used as a storehouse. It was a meritorious undertaking for the completion of the samples-store to convert these stables into bright dry places without great expenditure, accomplished by replacing the heavy wooden window frames and narrow iron grating with iron window frames freshly glazed, and by laying down a floor of cement on gravel which absorbed the rising damp in a completely satisfactory manner.

Now, by degrees, nearly all the space where the war horses used to neigh and the weapons clashed, has been converted into the peaceable abode of industrial produce; this space seems already too small, and the collection stands there as a query, what will be done further to set the progress of creative human skill before the eyes of the people of Württemberg? Now and again, it is true, a part of the sample-collection which has only temporary importance is removed to make space for another, but only a little room is gained by this, because this elimination has its narrow limits; seeing that the representation of the gradual process by which an industrial production is brought to perfection is of great value, and often the safest finger-post for further progress.

The use of the samples-store is arranged as follows:—

The sample-store is opened on week-days from 10 a.m. until noon and from 2 to 6 p.m. (in winter closing at dusk), on holidays it closes at 4 p.m., and is opened on Sundays from 10.30 to 12.30. The entrance is free.

In each hall is an attendant, whose duty is, when a visitor desires to inspect an object more closely, to give it him into his hands for a closer inspection, with due care. The attendant is most readily found by ringing a bell hung at the entrance to each room.

The objects in the samples-collections can be borrowed by manufacturers for a term of three weeks. But every borrower has on receipt of an object to sign a document by which he engages to preserve it carefully and keep it from damage, and, in case it gets damaged or altogether lost, to pay compensation settled by the provisions of the lending rules. Suggestion books are also laid open, in which everybody can give notice of his wishes respecting the provision of new samples, to which all possible attention will always be paid. It is desirable that the trading public especially should contribute in this way to the provision of objects of utility.

Wherever a trading society of any town in the country assists, or wherever else, with the help of the local authorities, the Central Institute has the opportunity of influencing the local trade beneficially, a collection of proper trade products is exhibited on the spot. The department of illustrated works has a special circulating library, which lends its books for four weeks' use to schools, trade societies, &c.

New objects procured are announced in the trade journal; in the same way, when, as recently happens with increasing frequency, ma-

chinery exhibited on their own account by foreign manufacturers is set in motion by the steam engine provided in the samples-store. There is also added to the sample-store a chemical laboratory and a lecture room, in which, on winter evenings, popular lectures are delivered on separate branches of industry. A further source for the supply of samples has been opened to our countrymen in the "Landes-gewerbe-halle" of Baden (commercial hall), between which and the samples-store an agreement has been made (not irrevocable however), by the terms of which the two institutes communicate their samples reciprocally on demand, for a proper consideration settled by a tariff, but at the same time, convey from one Institute to the other, at their own cost, such objects has have been temporally entrusted to them for exhibition by foreign exhibitors.

Our western neighbours have already been constant in their visits to our collections, and we may certainly hope that our own countrymen will not be behind them in the desire for information, and will on their part make good use of their treasures collected there.

K. Central-stelle für Gewerbe und
Stuttgart, 1 March 1867. Handel Steinbeis.

(*Preface from first Edition of Regulations.*)

APPENDIX B.

Direction of the National Museum of Bavaria.

Munich, 20th November 1873.

I find myself obliged before everything else to apologise for the delay that has occurred in forwarding the explanation requested by you per 30th September. The Conservator of the Museum, Dr. Kühn, wished to wait for my return with the report.

The National Museum of Bavaria, already projected by Maximilian II., in the year 1853, was founded in 1855, and owed its increase to the fact that the existing State collections, as well from the Royal Castles as from separate sources, placed at the disposal of the new institution their specimens of the productions of art and art trades, from the middle ages up to the time of Napoléon, in such quantity and importance that it took a prominent position among similar institutions.

To these are added acquisitions from private collections, as, for example, from that of Ainmiller; the celebrated collection of Herr von Reider in Lueneburg, the collection of the Erlangen university, and similar donations from private amateurs; also acquisitions by purchase from churches and old curiosity shops. Some towns also supported the Museum in the best way, by presentation of objects of antiquity in their possession.

The financial subsidies which the State added, amount at this date to about 120,000 florins=10,000*l.* sterling; 27,000 florins are allotted for the current year to the National Museum of Bavaria, for the payment of its management expenses and the salaries of officials, and the increase of the collections by purchase.

When the undersigned entered on office, considering that museums only fulfil their proper function when they become models and examples for contemporary fine art and commercial art productions, the Bavarian Musuem was reorganised; first the objects in it were severely sifted and more clearly arranged and the chronological principle more exactly

carried out, and then special departments were created for modern industry and art manufacture.

By this process the following subdivisions arose:—

1. Collection of Armour and Costumes.
2. „ „ Iron work and Smith's art.
3. „ „ Musical Instruments.
4. „ „ Brazier's work and Bismuth Painting.
5. „ „ Staple samples and Woven goods.
6. „ „ Ceramic Art.
7. „ „ Ornaments in Wood and Metal for art works in wood, gold, and silver, &c.

Afterwards, in order to procure good models for technical schools and the various art-trade works, a plaster of Paris workshop and photographic studio were established, and reproductions were made at a very low price, but of the best quality, and multiplied in so masterly a manner as to have attracted well-merited notice at the Vienna Exhibition.

This effort of the National Museum of Bavaria to influence in the first place our schools and modern art-industries and trades, induced me to take the further step of incorporating with the collections of the museum important and prominent productions of modern art-industry. In this way the manufacturer Giani in Vienna presented a collection of his stuffs from old patterns; the manufacturer Sältzer of Eisenach, a collection of his ceramic productions; the manufacturers Ebner and Gerdeissen, some of their samples of stuffs for ecclesiastical purposes, to the museum; and these are arranged along with the corresponding goods of earlier date. For the same purpose also, at the Vienna Exhibition, several purchases were made of similar modern productions of art-industry, only to a modest extent it is true, because we had only very inadequate means at disposal, and the Royal Government made us no further grant.

A. From the firm of *Elkington*, in Birmingham, we obtained—
   1. The Milton shield.
   2. Two salvers with the 12 months in galvanoplastic.

B. From the firm of *Mintons*—
   Model of a vessel of Henri II.
   Sundry tiles.

C. From the firm of *Minton and Hollins*—
   An assortment of tiles.

D. From the firm of *Salviati* in Venice—
   An assortment of Venetian glasses and the representation of Theodorich and Theodora, an ornament in glass mosaic from the church of S. Sophia.

E. From the iron works of Graf Stolberg—
   The helmet of Francis I., a reproduction.

A garden is attached to the collections of the National Museum of Bavaria, in which principally stone monuments of various epochs have been set up, so that it forms another museum in the open air. By these means we find, in the National Museum of Bavaria, not only the whole of human activity of earlier times fairly well represented, but also the attempt to illustrate the connexion between the fine art and art-industry of times long past and modern efforts in the same field; and for these reasons its collections are utilised in the most satisfactory manner by manufacturers and traders in art productions.

With distinguished respect,

(Signed) Dr. J. H. v. Hefner Alteneck.

APPENDIX C.

Compiled for this Report by HUGH WILLOUGHBY SWENY.

ABSTRACT showing the ACQUISITIONS, of which any record could be obtained, of MUSEUMS of ART and INDUSTRY by PURCHASES and GIFTS, together with the approximate sums expended at the VIENNA EXHIBITION of 1873.

PURCHASES.

		£	s.	d.	£	s.	d.
AUSTRO-HUNGARIAN EMPIRE.	1. K.K. OESTERREICHES GEWERBE MUSEUM, VIENNA	3,106	16	0			
	2. HANDELS MINISTERIUM (MINISTER OF COMMERCE), for Schools of Art in Austria	312	4	2			
	3. ATHENÆUM GEWERBE MUSEUM, VIENNA	30	0	0			
	4. BRÜNN INDUSTRIAL MUSEUM	90	6	0			
	5. FÖRST HOCH-SCHULE MARIABRÜNN	45	0	0			
	6. LEMBERG MUSEUM, GALICIA	30	0	0			
	7. CRACOW MUSEUM	4	0	0			
	8. KÜNST UND GEWERBE SCHULE, CARLSBAD	198	4	0			
	9. REICHENBURG SCHOOL OF INDUSTRY, BOHEMIA	29	0	0			
	10. LINZ MUSEUM	10	0	0			
	11. DEBRECZIN SCHOOL OF INDUSTRY	6	0	0			
HUNGARY	12. UNGARISCHES GEWERBE MUSEUM, MAGYAR IPAR MUSEUM, BUDA-PEST	3,167	16	4			
					7,029	6	6
BELGIUM.	13. MUSÉE D'ANVERS. No further returns.						
BRAZIL	14. RIO JANEIRO MUSEUM	12	0	0			
	15. BAHIA MUSEUM	10	0	0			
					22	0	0

		£	s.	d.	£	s.	d.
FRANCE.	16. Toulouse Museum				5	0	0
GERMAN EMPIRE	17. Deutsches Gewerbe Museum, Berlin	3,160	16	0			
	18. Königsberg Museum	15	0	0			
	19. Bayerisches Gewerbe Museum, Nürnberg	2,037	15	8			
	20. Bayerisches Gewerbe Museum, Munich	110	12	0			
	21. Carlsruhe Museum	244	0	0			
	22. Permanente Gewerbe Ausstellung, Hannover	214	17	2			
	23. Cassel Museum	54	10	0			
	24. University of Strasbourg	14	6	0			
	25. Modellir Schule, Dresden	34	0	0			
	26. Hanau Museum	16	8	4			
	27. Lubeck Museum	11	8	0			
	28. Leipsic Museum	4	0	0			
	29. Offentlichen Sammlungen, Stuttgart	888	16	6			
	30. Hamburg Museum	471	16	4			
	31. Darmstadt Museum	3	0	0			
					7,281	6	0
GREAT BRITAIN	32. Edinburgh Museum				1,104	10	2
ITALY	33. Milan Museum	65	16	8			
	34. Industrial Museum of Turin	16	0	0			
	35. Florence Museum	3	0	0			
					84	16	8
JAPAN.	36. Yeddo Museum. No full return.						
RUSSIA	37. Musée Impériale de St. Pétersbourg	423	16	8			
	38. Musée de Moscou	174	4	4			
	39. Helsingfors Museum	156	0	0			
					754	1	0
SWEDEN.	40. Stockholm Museum				10	0	0
TURKEY.	41. Constantinople School of Industry				10	0	0
UNITED STATES	42. Massachusetts Museum of Fine Arts, Boston	95	16	0			
	43. Carolina Museum. No further return	4	0	0			
					99	16	0
	Unknown Museums				57	0	2

DETAILS OF PURCHASES MADE BY, AND GIFTS TO, MUSEUMS.

PURCHASES.

No. 1.—K.K. OESTERREICHES GEWERBE MUSEUM, VIENNA, AUSTRIA.

		£	s.	d.
FRANCE		564	15	10
SPAIN		370	0	0
PERSIA	about	600	0	0
RUSSIA		34	16	0
GERMAN EMPIRE		64	4	0
AUSTRIA		245	18	0
DENMARK		3	10	0
ITALY		231	9	2
GREECE		15	0	0
SWITZERLAND	about	30	0	0
MOROCCO		408	0	0
HUNGARY		3	0	0
GREAT BRITAIN*		536	3	0
		3,106	16	0

FRANCE:	£	s.	d.
BARBEDIENNE, F., 30, Boulevard Poissonnière, Paris, clock, bronze doré, plaque enamel cloisonné	168	0	0
TH. DECK, 20, Passage des Favorites, Vaugirard, Paris, assiette Cupid	14	0	0
DENIÈRE, GUILLAUME, 15, Rue Vivienne, Paris, bronze statuette, "Diana and Pan," flambeaux, Renaissance	64	0	0
EMILE PHILLIPPE, 36, Rue Greneta, Paris, plateau repoussé	24	0	0
CHRISTOFLE & Co., 56, Rue de Bondy, Paris, vases and cups, encrusted in relief	64	0	0
GEOFFROY & Co., Gien, Loiret, pilgrim bottle, maiolica, and plates	12	0	0
POTTIER, 67, Rue Montorgueil, Paris, Limoges enamel on copper, Henri Deux, and 2 potiches, Limoges	164	0	0
AUBRY, Bellevue, near Toul, vases, socles, jardinière, and cornets, faïence	11	15	10
SOUPIREAU ET FOURNIER, 7, Rue Halle, Paris, sardinière	5	10	0
HACHE, ET PEPIN LEHALLEUR FRÈRES, 23, Rue de Paradis, Paris, dish and cups	4	1	8
ROUDILLON, 9, Rue Caumartin, chair, red velvet, Henri Deux, chair cuir and or, &c.	33	8	4
	564	15	10

* Gift of copy of "Milton's Shield."

AUSTRIA.

No. 1.—K.K. Oesterreiches Gewerbe Museum—*cont.*

	£	s.	d.
SPAIN:			
FABRICA DE ARMAS, Toledo, shield, iron repoussé, damascened with four battle pieces, on gold-grained ground; centre, Medusa's Head	300	0	0
PLACIDO ZULOAGA, Guipuscoa, iron coffer, damascened and encrusted	70	0	0
	370	0	0
PERSIA:			
VIENNA MUSEUM:			
Jade wine bottle, shaped like coffee pot, set with emeralds and rubies. Formerly used by the Schahs to drink wine without giving scandal to "True Believers." A rare curio.			
"Kach Koul" damascened in gold and chased. Very old and rare.			
"Satel" and "Aftabé-Lagan." Copper, engraved. Very old.			
Coffer in Pear wood.			
30 Pieces, copper bowls, &c. Old.			
Carpet, "Sedjadé."			
Carpet embroidered.			
about	600	0	0
RUSSIA:			
OFFTCHINNIKOFF, Moscow, large cup and saucer, gilt and enamelled	25	0	0
IMPERIAL GLASS FACTORY, St. Petersburg, goblet and bowl, green, gold and enamel	9	16	0
	34	16	0
GERMAN EMPIRE:			
GRAF SCHAFFGOTSCH, Josephinenhütte, Silesia, crystal and coloured glass	7	0	0
ROYAL PORCELAIN FACTORY, Berlin, tureen and stand, and round dish	7	4	0
VILLEROY AND BOCH, Mettlach, Luxembourg, clay mosaics, vases and plates	50	0	0
	64	4	0
AUSTRIA (Bohemia):			
GRAF HARRACH, Neuwelt, Bohemia, glass and goblet	2	18	0
ALOIS KLAMMERTH, Znaim, Moravia, imitation maiolica stone ware jugs, and "Ringers"	15	0	0
AUSTRIA:			
J. & L. LOBMEYR, 13, Kärntnerstrasse, Vienna, specimens of glass	120	0	0
MORITZ VON FISCHER, 18, Wallfischfasse, Vienna, porcelain ewer and basin, Turkish pattern, assiettes, &c.	40	0	0
AUGUST KLEIN, 20, Graben, Vienna, clock in bronze	48	0	0
SCHREIBER AND NEPHEWS, 22 and 24, Liechenstein-strasse, specimens of glass	20	0	0
	245	18	0

No. 1.—K.K. Oesterreiches Gewerbe Museum—*cont.* AUSTRIA.

	£	s.	d.
DENMARK:			
P. IPSEN'S WIDOW, Copenhagen, terra-cotta vases	3	10	0
ITALY:			
SALVIATI, MURANO, Venice, glass mosaic and glass	2	0	0
P. ANTONIBON & SON, Nove, Vicenza, fruit dish, cachepot ware, maiolica	3	12	6
MICHIELI & Co., Venice, fire dogs, "Neptune," bronze	15	0	0
GINORI Marchese, Doccia, plaque, candlesticks and plates, maiolica	30	16	8
CASTELLANI, Via di Poli, Rome, necklace	180	0	0
	231	9	2
GREECE:			
JEWELLERY and costumes	15	0	0
SWITZERLAND:			
E. HELLER, Berne, wood carvings	30	0	0
MOROCCO:			
GOLDWORK, from Timbuctoo, two collars, two bracelets, pair earrings	153	0	0
EMBROIDERY, old Moorish	225	0	0
TEXTILES	30	0	0
	408	0	0
HUNGARY:			
J. G. ZAHN, Zlatno, prismatic glass	3	0	0
GREAT BRITAIN:			
INDIAN DEPARTMENT, pottery, metal wares, jewellery, embroidery, arms, fabrics, carved wood	72	0	0
JOHN MORTLOCK, 203 & 204, Oxford Street	27	0	0
DANIELL & SON, Wigmore Street	30	11	0
COPELAND & SONS, 160, New Bond Street	8	8	0
ELKINGTON & Co., Birmingham	272	10	0
MINTONS, Stoke-on-Trent	125	14	0
	536	3	0

GIFTS.

No. 1.—K. K. OESTERREICHES GEWERBE MUSEUM, VIENNA.

SPAIN:

GIFT of 8 vases of terra-cotta, Balearic Islands.

AUSTRIA:

HOFFMANN, Prague, beer goblet.

SCHREIBER & NEPHEWS, specimens of glass, value about 35*l.*

AUSTRIA.

No. 1.—Oesterreiches Gewerbe Museum—*continued.*

EGYPT:

GIFT from the Khédive of the Egyptian section, *en bloc.*

SPECIMENS.—Raw petroleum, salts and nitre, minerals, marbles and stones, cereals, herbs and seeds, tobacco, sugar cane, and samples of raw products, chemical preparations, food substances, textiles and clothing, leather, metal work, pottery, porcelain and glass, works in ivory, mother-o'-pearl and amber, 49 samples of paper made in the Khedive's mills, photographs of types of national character, musical instruments, building materials, models of dwelling houses, school books, plan in relief of Egypt, and South Egypt Exhibition.

TURKEY:

LARGE COLLECTION OF POTTERY, specimens from various provinces of Empire, about 400 pieces.

GREAT BRITAIN:

ELKINGTON & Co., Birmingham, copy of the "Milton Shield." Cloisonné and Champlevé enamels.

PURCHASES.

No. 2.—HANDELS MINISTERIUM (MINISTER OF COMMERCE), for Schools of Art in Austria.

	£	s.	d.
FRANCE:			
DENIÈRE, bronze escalier, flambeaux, Renaissance -	247	4	2
AUSTRIA:			
LOBMEYR, specimens of glass - - - -	65	0	0
	312	4	2

Many more purchases were made, but as a rule the purchases were effected privately; full information could not be obtained. It is known, however, that a large sum, no less than 5000*l.*, was allocated for the purpose of making purchases.

GIFTS.

No. 2.—HANDELS MINISTERIUM (MINISTER OF COMMERCE), for Schools of Art in Austria.

GREECE:

GIFT of marbles, woods, seeds, minerals, oils, and wines.

CHINA:

Gift to Ackerbau Ministerium, Austria.

Seeds. Barks and fibres.
Peasants' cloaks of fibres.

No. 2.—Handels Ministerium—*cont.* AUSTRIA.

Coal.
Mining, blacksmiths' and joiners' tools. Two cases.
Printed papers, paper flowers, and ornaments. Five cases.
Maps, coloured. Stamped papers.
Moulds of types. Books. Three large cases.
Skins.
Embroideries.
Curios of various kinds.

INDIAN DEPARTMENT:

GIFT of raw materials from India to the Minister of Commerce and Minister of Agriculture in Vienna, to be divided into two complete series.

45 samples of teas in bottles.
15 „ narcotics in bottles.
22 „ spirits in bottles.
109 „ grains and pulses in bottles.
3 „ spices, &c. in bottles.
14 „ sugars.
2 „ vinegars.
24 „ oil seeds.
10 „ coffees.
21 „ oils in bottles.
Collection of fibres.
Specimens of tobacco.
211 specimens of Indian woods (some of which are to be handed over to the Forest Department at Mariabrünn).

PURCHASES.

No. 3.—ATHENÆUM GEWERBE MUSEUM, VIENNA.

	£	s.	d.
AUSTRIA:			
SCHREIBER & NEPHEW, specimens of glass, about -	30	0	0

GIFTS.

No. 3.—ATHENÆUM GEWERBE MUSEUM, VIENNA.

HOLLAND:
GIFT of Colonial trophy of barks, seeds, and woods.

AUSTRIA:
SCHREIBER & NEPHEW, gift of glass, about 50*l.*

AUSTRIA.

No. 3.—Athenæum Gewerbe Museum, Vienna.—*cont.*

GREAT BRITAIN:

GIFT from Indian Department to Baron Schwarz, for the Athenæum of Vienna.

24 samples of oil seeds.
38 „ dyes.
38 „ seeds, &c.
127 „ grains, pulses, &c.
Collection of fibres.
Clay models of agricultural works, &c.
Models of agricultural implements.
50 specimens of Indian woods.
Collection of figures of the natives of India.

The whole of the collection of raw products imported into Great Britain in 1871, exhibited by Her Majesty's Royal Commissioners, cost 350*l.*

The collection of seaweed products shown by the British Seaweed Company, and

Mr. Ed. C. C. Stanford's products obtained from human excreta by his seaweed charcoal system of sewage utilisation, valued at 100*l.*

The collection of essences, flavouring materials, and condiments, exhibited by Mr. Jno, Mackay of Edinburgh, valued at 80*l.*

A series of diagrams exhibited by Messrs. A. K. Johnstone, of Edinburgh, valued at 6*l.*

The foreign contributions to Baron Schwarz-Senborn's projected Athenée were doubtless very numerous but no list has been obtained.

PURCHASES.

No. 4.—BRÜNN INDUSTRIAL MUSEUM.

	£	s.	d.
FRANCE	17	10	0
RUSSIA	0	14	0
DENMARK	20	6	0
GERMAN EMPIRE	6	16	0
ITALY	5	0	0
AUSTRIA	40	0	0
	90	6	0

FRANCE:

SERGENT, TH., 106, Avenue d'Orleans, Paris, coffer, Byzantine	1	10	0
LÉON PARVILLÉE, 1 Rue Neuve Fontaine, St. Georges, plaque, Moresque design	12	0	0
DECK, TH., Paris, faïence	4	0	0
	17	10	0

No. 4.—Brünn Industrial Museum—*cont.* AUSTRIA.

	£	s.	d.
RUSSIA:			
KHLEBNIKOFF, Moscow, spoon, enamelled and gilt	0	14	0
DENMARK:			
ROYAL PORCELAIN FACTORY, 1 figure, 3 bas-reliefs, biscuit	1	18	0
P. IPSEN'S WIDOW, 4 vases, 2 cups, 1 bottle, terra-cotta	15	0	0
V. WENDRICH, Copenhagen, 4 vases, terra-cotta	3	8	0
	20	6	0
GERMAN EMPIRE:			
ROYAL BERLIN FACTORY, dish, tureen, and stand	6	16	0
ITALY:			
MICHIELI & Co., Venice, plaque and small candlestick	5	0	0
AUSTRIA:			
J. & L. LOBMEYR, Vienna, specimens of glass	25	0	0
SCHREIBER & NEPHEW, Vienna, specimens of glass	15	0	0
	40	0	0

GIFTS.

No. 4.—BRÜNN INDUSTRIAL MUSEUM.

SCHREIBER & NEPHEWS, specimens of glass, about	35	0	0

PURCHASES.

No. 5.—FÖRST HOCH-SCHULE, MARIABRÜNN.

ITALY:			
MARCHESE GINORI, specimens of porcelain	15	0	0
HUNGARY:			
KARL BENTLER, Hermannstadt, woodwork and parqueterie	30	0	0
	45	0	0

GIFT.

No. 5.—FÖRST HOCH SCHULE MARIABRÜNN

SWEDEN:

Large Wooden Screen from Swedish Commission.

AUSTRIA.

PURCHASES.

No. 6.—LEMBERG MUSEUM, GALICIA.

AUSTRIA:	£	s.	d.
LOBMEYR, specimens of glass - - - -	30	0	0

PURCHASES.

No. 7.—CRACOW MUSEU

FRANCE:			
TH. DECK, faïence - - - - - -	4	0	0

PURCHASES.

No. 8.—KÜNST GEWERBE SCHULE, CARLSBAD (SCHOOL OF ARTS AND INDUSTRY, CARLSBAD).

FRANCE - - - - - - - - -	115	2	0
ITALY - - - - - - - -	20	0	0
GREAT BRITAIN - - - - - -	63	2	0
	198	4	0

FRANCE:			
TH. DECK, Paris, assiettes, plaques, vase, pilgrim bottle - - - - - - -	59	0	0
ROUSSEAU, 41, Rue Coquillière, bottles and vases, cloisonné enamels on faïence - - - -	13	12	10
COLLINOT, 13, Rue Royale, Paris, faïence, small slab and vases - - - - - - -	14	4	2
SOUPIREAU & FOURNIER, Paris, jardinière, Italian faïence - - - - - - -	3	10	0
HACHE & PEPIN LEHALLEUR FRÈRES, Paris, 3 pairs cups, 5 assiettes - - - - - -	9	12	6
JULES HOURY, 37, Boulevard Strasbourg, plates, Henri Deux, and other objects, some hand-painted -	15	2	6
	115	2	0

ITALY:			
SALVIATI, Venice, glass mosaics and glass - -	20	0	0

GREAT BRITAIN:			
MINTONS, Stoke-upon-Trent, specimens of porcelain	63	2	0

PURCHASES.

AUSTRIA.

No. 9.—Reichenberg School of Industry.

	£	s.	d.
FRANCE - - - - - - - -	4	0	0
AUSTRIA - - - - - - - -	15	0	0
GERMAN EMPIRE - - - - - -	10	0	0
	29	0	0

FRANCE:

Th. Deck, Paris, faïence - - - - - 4 0 0

AUSTRIA:

J. & L. Lobmeyr, Vienna, specimens of glass - 10 0 0

Alois Klammerth, Znaim, imitation maiolica and "Ringers" - - - - - - - 5 0 0

15 0 0

GERMAN EMPIRE:

Villeroy & Boch, Mettlach, mosaic work in glass vases and plates - - - - - 10 0 0

PURCHASES.

No. 10.—Linz Museum.

AUSTRIA:

Schreiber & Nephews, specimens of glass - - 10 0 0

GIFT.

No. 10.—Linz Museum.

Gift from Schreiber & Nephews, about 20*l.*

PURCHASES.

No. 11.—Debreczin School of Industry.

PORTUGAL:

Cerquinho de Silveira, Oporto, filigree jewellery 3 0 0

Henri Burnay, Lisbon, peasant jewellery, filigree - 3 0 0

6 0 0

HUNGARY.

PURCHASES.

No. 12.—MAGYAR IPAR MUSEUM.—UNGARISCHES GEWERBE MUSEUM.

	£	s.	d.
FRANCE - - - - - - -	473	8	4
SPAIN - - - - - - -	209	0	0
PERSIA - - - - - - -	224	0	0
RUSSIA - - - - - - -	155	16	0
PORTUGAL - - - - - -	5	0	0
GERMAN EMPIRE - - - - -	76	0	0
AUSTRIA - - - - - - -	270	0	0
DENMARK - - - - - -	54	6	0
ITALY - - - - - - -	655	0	6
GREECE - - - - - - -	600	0	0
HUNGARY - - - - - -	5	0	0
GREAT BRITAIN - - - - -	440	5	6
	3,167	16	4

FRANCE:

MORISOT, Paris, fire dog, iron and copper, polished *à jour* - - - - - -	20	0	0
EMILE PHILIPPE, 76, Rue de Turenne, Paris, bonbonnière, silver encrusted, with gold album, and buvard, Byzantine, enamel bronze, coffer and cup - -	36	0	0
GEOFFROY & Co., Gien, Loiret, 2 vases, faïence Rouen, and service "Gien" - - - - - -	12	0	0
BERCHOUD & GUERREAU, 25, Rue du Moine, Paris, chair seat, velvet, savonnière - - -	14	0	0
BROCARD, 94, Rue du Sèvres, fish dish, dish, enamel on glass - - - - - -	24	0	0
POTTIER, Paris, potiche, Limoges, 2 vases, Francis I., plate, Henri Deux, 'Moustier,' containing basin, flower on purple ground, and small bowl, Oriental -	23	8	4
BARBIZET, 15, Place du Trone, vases, imitation Palissy ware - - - - - - - -	4	0	0
FOURDINOIS, 46, Rue Amelot, panel, wood encrusted and carved, "Venus and Cupid" - - -	120	0	0
DECK, Paris, faïence - - - - -	20	0	0
SERVENT, 137, Rue Vieille du Temple, bronze group, "Bellerophon and Pegasus" - - -	200	0	0
	473	8	4

No. 12.—Magyar Ipar Museum.—Ungarisches GewerbeMuseum—*cont.* HUNGARY.

	£	s.	d.
SPAIN:			
JOSÉ RODRIGUEZ ZURDO, Madrid, saddle, raised, Maltese work, Moresque pattern	80	0	0
FABRICA DE ARMAS, Toledo, Toledo sword with basket hilt, iron chased, gilt, damascened and enamelled	49	0	0
PLACIDO ZULOAGA, Guipuscoa, vase and cup, encrusted and damascened, gold and silver	80	0	0
	209	0	0
PERSIA:			
MANUSCRIPTS, carpets, and embroidery	224	0	0
RUSSIA:			
IMPERIAL Glass Factory, beer jug and 6 glasses, vases	31	16	0
KIILEBNIKOFF, Moscow, cups, gilt, enamelled and niello	24	0	0
F. CHOPIN, St. Petersburg, chandelier, bronze, oxydised	100	0	0
	155	16	0
PORTUGAL:			
HENRI BURNAY, peasant jewellery	5	0	0
GERMAN EMPIRE:			
GRAF SCAAFFGOTSCH, glass, crystal and colored glass	1	0	0
ROYAL PORCELAIN FACTORY, Berlin, 2 biscuit vases and pedestals	3	0	0
ROYAL PORCELAIN FACTORY, Meissen, grand and small vase, fruit stand and plate	42	0	0
VILLEROY & BOCH, plates, mosaic in clay	30	0	0
	76	0	0
AUSTRIA:			
M. KLEIN, Stephansplatz, Vienna, leather work	60	0	0
J. & L. LOBMEYR, Vienna, specimens of glass	180	0	0
IGNAS LUKSCH, 16, Myrthengasse, Vienna, leather work	5	0	0
SCHREIBER & NEPHEWS, Vienna, specimens of glass	25	0	0
	270	0	0
DENMARK:			
CHRISTESEN, Copenhagen, jewellery, after Scandinavian and Celtic models, Celtic brooches and bracelet	54	6	0

HUNGARY. No. 12.—Magyar Ipar Museum.—Ungarisches Gewerbe Museum—*cont.*

	£	s.	d.
ITALY:			
SALVIATI, Venice, glass mosaics and glass	220	0	0
MICHIELI & Co., Venice, bronze candelabra, vases, lamp, plaque, and sundry small objects	350	0	0
GINORI, Doccia, ewer and plateau, Raffaelle ware, cups, wares, cachepot, Italian faïence	32	8	4
CASTELLANI, Rome, brooch, earrings, Etruscan, brooch with cameos	41	4	2
SALVO & SON, Genoa, collar and earrings, filigree	6	0	0
GIUSEPPE PELLAS, Florence, coffer and plaque, electro deposit	5	8	0
	655	0	6
GREECE:			
200 Plaster Casts of statues and bas-reliefs from Parthenon, and ancient monuments of Athens	600	0	0
	600	0	0
HUNGARY:			
WILHELM ZSOLNAY, Fünfkirchen (Pecs) pottery and stone ware	5	0	0
GREAT BRITAIN:			
INDIAN DEPARTMENT, jewellery, arms, pottery	160	0	0
JAMES GREEN & Co., specimens of glass	22	8	6
WEDGWOOD, Wedgwood ware	32	10	0
DANIEL & SON, specimen of porcelain	1	5	0
ELKINGTON & Co., electrotypes of art-works	107	12	0
MINTONS, specimens of porcelain	116	10	0
	440	5	6

GIFTS.

No. 12.—MAGYAR IPAR MUSEUM.—UNGARISCHES GEWERBE MUSEUM.

AUSTRIA:

SCHREIBER & NEPHEWS, gift of glass, about 40*l.*

HUNGARY:

JOSEF HOLLANDER, Pest, meerschaum pipe, with carvings of eight horses and two riders, with amber medallions, cut in intaglio, and boars' and stags' heads let in. Finest pipe shown in the Exhibition, value about 100*l.*

PURCHASES.

No. 13.—Musée D'Anvers.—Antwerp Museum. Belgium.

ITALY:	£	s.	d.
Salviati, Venice, glass mosaic and glass - -	3	0	0

PURCHASES.

No. 14.—Rio Janeiro Museum.

PORTUGAL:				Brazil.
Cerquinho y Silveira, Oporto, filigree jewellery -	5	0	0	
Henri Burnay, Lisbon, peasant jewellery and figures, types of peasant costumes - - - -	7	0	0	
	12	0	0	

GIFTS.

No. 14.—Rio Janeiro Museum.

Gift from India Department of samples of raw products, to Brazil, divisible into two or more complete series.

45 samples of grains and pulses.
16 „ teas.

PURCHASES.

No. 15.—Bahia Museum.

AUSTRIA:	£	s.	d.
Ignaz Luksch, Vienna, leather-work - -	10	0	0

PURCHASES.

No. 16.—Toulouse Museum. France.

DENMARK:			
Hôme Industry, collective exhibition in fish-scale embroidery, tools, carved wood; all peasants' work -	5	0	0

GERMAN EMPIRE.

PURCHASES.

No. 17.—DEUTSCHES GEWERBE MUSEUM, BERLIN.

	£	s.	d.
FRANCE	634	15	2
SPAIN	275	0	0
PERSIA	800	0	0
RUSSIA	442	8	0
PORTUGAL	22	0	0
GERMAN EMPIRE	21	10	0
DENMARK	15	16	0
ITALY	359	13	4
GREECE	50	0	0
TURKEY	33	0	0
AUSTRIA	60	0	0
HUNGARY	60	0	0
GREAT BRITAIN	386	13	6
	3,160	16	0

FRANCE:

	£	s.	d.
BARBEDIENNE, Paris, 2 Limoges enamels, subjects, "Battle" and "Warrior"	96	0	0
TH. DECK, Paris, small porte-bouquet, polychrome	3	0	0
MORISOT, 76, Rue de Turenne, Paris, fire dog, iron and copper, polished *à jour*	20	0	0
EMILE PHILIPPE, Paris, flaçon, Persian, cloisonné enamel	14	0	0
GEOFFROY & Co., Gien, aiguière and plateau, Italian maiolica	8	0	0
CHRISTOFLE & Co., Paris, service and tray, enamelled and gilt	48	0	0
WOODCOCK, Rue de Paris, Poissonnière, Paris, porcelain rose	0	12	6
EUGÈNE CORNU & Co., 29, Rue Popincourt, Paris, box, Renaissance fantaisie, polished copper	48	0	0
BERCHOUD & GUERREAU, chair seat, red pattern	3	4	2
COLLINOT, 13, Rue Royal, Paris, jardinière, blue turquoise ground, cloisonné enamel on faïence	40	0	0
BROCARD, 94, Rue de Sèvres, Paris, saladier and lamps, enamel on glass, colors and gold	66	8	4
POTTIER, Paris, coffer and bowl, enamel	19	4	2
HACHE ET PÉPIN LEHALLEUR FRÈRES, Paris, 2 cups, 1 dish	3	16	0
Carried forward	370	5	2

No. 17.—Deutsches Gewerbe Museum, Berlin—*cont.*

GERMAN EMPIRE.

	£	s.	d.
Brought forward - -	370	5	2
BRIANCHON AINÉ, 201, Quai Valmy, Paris, basin and jug, porcelain nacré - - - - - -	4	10	0
LÉON PARVILLÉE, Paris, plaque, Moresque design -	20	0	0
ROUDILLON, Paris, cabinet, wood, encrusted and carved - - - - - - -	220	0	0
DUPLAN & Co., 75, Rue Richelieu, panel of Aubusson, tapestry - - - - - -	20	0	0
	634	15	2
SPAIN:			
LUCIANO GARCIA DORADO, Valladolid, saddle, leather mosaic, yellow, red, and blue - -	25	0	0
PLACIDO ZULOAGA, Guipuscoá, vase, coffer, and perfume vase, iron, damascened gold and silver -	250	0	0
	275	0	0
PERSIA:			
Ancient vases and other objects. Carpets and "Hotam" work - - - - -	800	0	0
RUSSIA:			
A. POSTNIKOFF, Moscow, 2 spoons and cream jug, gilt and enamelled - - - - about	56	0	0
J. TSCHITSCHELEFF, Moscow, coffee cup and saucer, gilt and enamelled, and tiara, Byzantine, gold, open-worked, enamelled blue, red, and green, set with rubies and pearls, below interlaced chain of pearls -	350	0	0
KHLEBNIKOFF, Moscow, salt box, niello, and cigar case, gilt and enamelled, and niello - - -	36	8	0
	442	8	0
PORTUGAL:			
CERQUINHO Y SILVEIRA, Oporto, filigree jewellery -	5	0	0
MOURÃO Y IRMAO, Lisbon, filigree star and cross -	10	0	0
HENRI BURNAY, Lisbon, peasant jewellery - -	5	0	0
„ „ figures, types of national costume - - -	2	0	0
	22	0	0
GERMAN EMPIRE:			
GRAF SCHAFFGOTSCH, Josephinenhütte, crystal and coloured glass - - - - - -	1	10	0
VILLEROY & BOCH, Mettlach, vases and plates in clay mosaic - - - - - - -	20	0	0
	21	10	0
DENMARK:			
CHRISTESEN, Copenhagen, bracelet, filigree relief -	15	16	0

GERMAN EMPIRE.

No. 17.—Deutsches Gewerbe Museum, Berlin—*cont.*

	£	s.	d.
ITALY:			
SALVIATI, Venice, glass mosaics and glass	30	0	0
P. ANTONIBON & SON, Nove Vicenza, maiolica dishes and plaques	5	13	4
ZALAFFI, Sienna, appliqué, griffon in bronze	65	0	0
MICHIELI & Co., Venice, bronze plaque	5	0	0
GINORI, Doccia, candelabra and vases, ewers and cachepot	66	0	0
CASTELLANI, Rome, necklace and earring, cupid on dove	188	0	0
	359	13	4
GREECE:			
JEWELLERY and COSTUMES	50	0	0
TURKEY:			
MOSAIC in cloth, and about 35 pieces of pottery	33	0	0
AUSTRIA:			
M. KLEIN, Vienna, leather-work	15	0	0
J. & L. LOBMEYR, Vienna, specimens of glass	10	0	0
IGNATZ LUKSCH, Vienna, album, bronze cover, open work	25	0	0
SCHREIBER & NEPHEWS, Vienna, specimens of glass	10	0	0
	60	0	0
HUNGARY:			
PAUL CZEGLÉDY, Torda Alanyosen, various potteries	10	0	0
MARTIN BORZY, Lander Verein, various potteries	10	0	0
JOSEF KOVÁCS, Mezötur, various potteries	10	0	0
BERTHALOMEUS KEREKGYARTO, Mezötier, leather peasant coat, "Bèke" and belts	10	0	0
CARL SCHOCTERUS, Miskalcz, peasant woman's "Bèke"	15	0	0
WILHELM ZSOLNAY, Hermannstadt, Fünfkirchen, pottery	5	0	0
	60	0	0
GREAT BRITAIN:			
INDIAN DEPARTMENT, pottery, jewellery, embroidery, &c.	120	0	0
JAMES GREEN, London, glass	0	10	6
JOSIAH WEDGWOOD, Etruria, Wedgwood	12	10	0
ELKINGTON & Co., Birmingham, art-specimens, electro	204	5	0
MINTONS Stoke-on-Trent, to Ceramic Museum porcelain	4	4	0
„ Deutsches Gewerbe, porcelain	45	4	0
	386	13	6

GERMAN EMPIRE.

GIFTS.

No. 17.—DEUTSCHES GEWERBE MUSEUM, BERLIN.

AUSTRIA:

GIFT of glass from Schreiber & Nephews, about 25*l.*

GREAT BRITAIN:

GIFT of grain and raw products from Indian Department, to the Agricultural Museums of Berlin and Munich, divisible into two or more complete series.

92 samples of grains and pulses.
3 „ coffees.
26 „ oil seeds.
11 „ spices, &c.
18 „ sugars.
20 „ teas.
30 „ miscellaneous pickles.
Collection of fibres.
40 specimens of Indian woods.

PURCHASES.

No. 18.—KÖNIGSBERG MUSEUM.

	£	s.	d.
AUSTRIA:			
M. KLEIN, leather-work - - - -	15	0	0

PURCHASES.

No. 19.—BAYERISCHE GEWERBE MUSEUM, NÜRNBURG.

FRANCE - - - - - - -	745	5	8
PERSIA - - - - - - -	400	0	0
RUSSIA - - - - - - -	90	2	0
PORTUGAL - - - - - - -	12	0	0
GERMAN EMPIRE - - - - -	115	4	0
AUSTRIA - - - - - - -	85	0	0
ITALY - - - - - - -	80	0	0
DENMARK - - - - - - -	1	0	0
TURKEY - - - - - - -	26	0	0
HUNGARY - - - - - - -	10	0	0
GREAT BRITAIN - - - - -	473	4	0
	2,037	15	8

GERMAN EMPIRE.

No. 19.—Bayerische Gewerbe Museum, Nürnburg—*cont.*

FRANCE:	£	s.	d.
BARBEDIENNE, Paris, 2 "bagniers" bronze, bonbonnière, cloisonné enamel	19	0	0
TH. DECK, Paris, assiette and porte-bouquet	14	8	4
AUGUSTE LEMAIRE, 121, Rue Vieille du Temple, Paris, large cup, griotte marble, with bronze wreaths, Louis XIV., and 2 busts, "Coup de Vent" and "Coup de Pluie"	104	0	0
BLOT & DROUARD, 8, Rue des Enfants Rouges, Paris, vases, cachepot, and 4 birds on panels	39	16	8
G. SERVANT, Paris, vase, cloisonné enamel	14	4	2
HENRI PERROT, 5, Rue Charlot, Paris, inkstand and candlesticks, copper polished, Louis XIV.	48	0	0
EMILE PHILIPPE, Paris, coffer, Byzantine, cloisonné enamel, and flaçon, Renaissance	40	0	0
GEOFFROY & Co., Gien, grand vase and jardinière, Rouen faïence, vase, Italian faïence	26	0	0
CHRISTOFLE & Co., Paris, inkstand, vase, and service	72	0	0
ROUSSEAU, Paris, enamels and porcelain, Limoges enamel on copper, "Faust and Marguerite," vases faïence, and slabs "pâte sur pâte"	68	10	10
COLLINOT, Paris, vase and jardinière, cloisonné enamel on faïence	15	4	2
BROCARD, Paris, enamelled glass, saladier, glass, and dish	52	0	0
GAGNEAU, 115, Rue de Lafayette, Paris, copper polished candelabra and cassolette, Louis XIV.	104	10	0
POTTIER, Paris, cup, Limoges enamels and bonbonnière, Louis XV.	23	4	2
HACHE, ET PEPIN LEHALLEUR, Paris, porcelain cups	1	4	2
BRANCHON AINÉ, Paris, Nacré porcelain, basin and jug, salt cellar and cup	5	14	0
LAURIN, Bourg-la-Reine, faïence, 2 potiches, vase and cachepot	11	6	8
BARBIZET, Paris, Palissy ware, group, dish and pair of candlesticks	10	16	8
LÉON PARVILLÉE, Paris, enamels on pottery, plaque	12	0	0
JULES HOURY, 37, Boulevard Strasbourg, Paris, faience, plaques and bonbonnière	19	8	4
PAUTROT & VALLON, 13, Boulevard du Temple, Paris, bronze cock and lizard, finely chased	6	4	2
LEVY, 29, Rue Sevigné au Marais, Paris, 2 vases, bronze, polished, Griotte marble stands, Renaissance	4	16	8
SCHLOSSMACHER & SON, 19, Rue Béranger, Paris, 2 vases, Sèvres	33	16	8
	745	5	8

PERSIA:			
Manuscripts, mosaics, writing boxes, and carpets	400	0	0

No. 19.—Bayerische Gewerbe Museum, Nürnburg—*cont.*

GERMAN EMPIRE.

	£	s.	d.
RUSSIA:			
TSCHITSCHELEFF, Moscow, coffee cups and saucers; gilt and enamelled	40	0	0
CHOPIN, St. Petersburg, bronze statuette "Don Cossack on horseback"	6	0	0
IMPERIAL GLASS FACTORY, punch bowl, tray, and 6 glasses, steel blue ground, enamelled in brown, yellow, and green, with gilt lines	26	2	0
KHLEBNIKOFF, Moscow, 2 spoons, gilt and enamelled	18	0	0
	90	2	0
PORTUGAL:			
CERQUINHO Y SILVEIRA, Oporto, filigree jewellery	5	0	0
HENRI BURNAY, Lisbon, peasant jewellery	5	0	0
HENRI BURNAY, Lisbon, figures, types of national costumes	2	0	0
	12	0	0
GERMAN EMPIRE:			
GRAF SCHAFFGOTSCH, crystal and coloured glass	10	0	0
ROYAL BERLIN FACTORY, tête-à-tête service, with views of Potsdam	22	10	0
ROYAL SAXON FACTORY, grand vase, with flowers painted, and small vase	31	10	0
PFORZHEIM COLLECTION, gold jewellery	11	4	0
VILLEROY & BOCH, clay mosaic ware	40	0	0
	115	4	0
AUSTRIA:			
M. KLEIN, Vienna, leather-work	15	0	0
LOBMEYR, Vienna, specimens of glass	50	0	0
SCHREIBER & NEPHEWS, specimens of glass	20	0	0
	85	0	0
ITALY:			
BASSANO, Venice, beads, glass	2	0	0
SALVIATI, Venice, glass mosaic, and glass	40	0	0
GINORI, ewer and vases, maiolica	38	0	0
	80	0	0
DENMARK:			
ROYAL PORCELAIN FACTORY, Copenhagen, cups and other small specimens	1	0	0
TURKEY:			
Scissors, writing book, carpet, and painted boxes	26	0	0

GERMAN EMPIRE.

No. 19.—Bayerische Gewerbe Museum, Nürnburg—*cont.*

	£	s.	d.
HUNGARY:			
M. LADÁNYI, Klausenburg "Kalozsveir," near Antonsthal, pottery	5	0	0
J. G. ZUHN, Zlatno, glass prismatic surfaces	5	0	0
	10	0	0
GREAT BRITAIN:			
JAMES GREEN, glass	5	18	0
WORCESTER PORCELAIN FACTORY, porcelain	13	15	0
JOHN MORTLOCK, Porcelain	30	13	0
ELKINGTON & Co., artistic work in electro	286	2	0
MINTONS, porcelain	136	16	0
	473	4	0

GIFTS.

HOFFMANN PRAGUE, bottles and glasses.
SCHREIBER & NEPHEWS, glass, about 40*l.*

No. 20.—BAYERISCHE GEWERBE MUSEUM, MUNICH.

	£	s.	d.
ITALY	28	0	0
GREECE	20	0	0
GERMAN EMPIRE	1	0	0
GREAT BRITAIN	61	12	0
	110	12	0
ITALY:			
BASSANO, Venice, glass beads	8	0	0
SALVIATI, Venice, glass mosaics and glass	20	0	0
	28	0	0
GREECE:			
Jewellery and Costumes	20	0	0
GERMAN EMPIRE:			
GRAF STOLBERG, Wernigowdische Factory, Hamburg, helmet, Francis I.	1	0	0
GREAT BRITAIN:			
ELKINGTON & Co., Birmingham, works of art in electro	40	12	0
MINTONS, Stoke-on-Trent, porcelain	21	0	0
	61	12	0

No. 20.—Bayerische Gewerbe Museum, Munich—*cont.* GERMAN EMPIRE.

GIFTS.

From Indian Department to the Agricultural Museums of Berlin and Munich, divisible into two or more complete series.

92 samples of grains and pulses.
3 „ coffees.
26 „ oil seeds.
11 „ spices, &c.
18 „ sugars.
20 „ teas.
30 „ miscellaneous pickles.
Collection of fibres.
40 specimens of Indian woods.

PURCHASES.

No 21.—CARLSRUHE MUSEUM.

	£	s.	d.
FRANCE - - - - - - -	49	0	0
GERMAN EMPIRE - - - - -	10	0	0
AUSTRIA - - - - - -	165	0	0
HUNGARY - - - - - -	20	0	0
	244	0	0

FRANCE:

THEODORE DECK, Paris, porte-bouquet, cup, plaque and vase, polichrome enamel - - - 49 0 0

GERMAN EMPIRE:

ROYAL SAXON PORCELAIN FACTORY, figures - 10 0 0

AUSTRIA:

J. & L. LOBMEYR, Vienna, specimens of glass - 25 0 0
M. KLEIN, Vienna, leather-work - - - 140 0 0
165 0 0

HUNGARY:

P. CZEGLÉDY, T. A. Lander Verein, potteries - 5 0 0
MARTIN BORZY, Mezötur, potteries - - - 5 0 0
JOSEF KOVACS, Mezötur, potteries - - - 5 0 0
W. ZSOLNAY, Fünfkirchen, potteries - - - 5 0 0
20 0 0

GERMAN EMPIRE.

PURCHASES.

No. 22.—PERMANENTE GEWERBE AUSSTELLUNG, HANNOVER.

	£	s.	d.
FRANCE	97	14	2
GERMAN EMPIRE	10	10	0
ITALY	20	0	0
AUSTRIA	25	10	0
GREAT BRITAIN	61	3	0
	214	17	2

FRANCE

BARBEDIENNE, Paris, gueridon, with black marble top, Medusa's head in centre	72	0	0
POTTIER, Paris, vases, Francis I.	14	0	0
BRIANCHON, AINÉ, Paris, basin and jug	7	10	0
JULES HOURY, Paris, pair baguières, coffer, plaque and cendriers	4	4	2
	97	14	2

GERMAN EMPIRE:

ROYAL SAXON PORCELAIN FACTORY, Meissen	10	10	0

ITALY:

SALVIATI, Venice, glass mosaics and glass	20	0	0

AUSTRIA:

AUGUST KLEIN, Vienna, blotting book, leather-work	25	10	0

GREAT BRITAIN:

PELLATT & WOOD, London, glass	8	10	0
COPELAND & SONS, London, porcelain	11	3	0
ELKINGTON & Co., Birmingham, art-works in electro	18	0	0
MINTONS, Stoke-on-Trent, porcelain	23	10	0
	61	3	0

PURCHASES.

No. 23.—CASSEL MUSEUM.

SWEDEN	3	0	0
DENMARK	24	10	0
ITALY	7	0	0
AUSTRIA	5	0	0
GERMAN EMPIRE	15	0	0
	54	10	0

No. 23.—Cassel Museum—*cont.*

	£	s.	d.
SWEDEN:			
RÖRSTRAND, Stockholm, 2 vases, maiolica, and porcelain plate, with flowers	3	0	0
DENMARK:			
HOME INDUSTRY, fish scale embroidery, tools, carved wood, all peasant's work	5	0	0
METAL WIRE FACTORY, Copenhagen, wireworks, tinned	1	12	0
J. E. MEYER, Copenhagen, japanned trays	1	18	0
D. L. CLEMENT, Copenhagen, Bible for the binding	3	10	0
CLAUSEN, Copenhagen, gold brooch	2	0	0
GEO. HESSE, Copenhagen, vases, black, with flowers painted, polichrome	4	10	0
P. IPSEN'S WIDOW, Copenhagen, 2 vases, terra-cotta	3	10	0
V. WENDRICH, Copenhagen, 3 vases	2	10	0
	24	10	0
ITALY:			
SALVIATI, Venice, glass mosaics and glass	7	0	0
AUSTRIA:			
LOBMEYR, Vienna, specimens of glass	5	0	0
GERMAN EMPIRE:			
VILLEROY & BOCH, Mettlach, clay mosaics	15	0	0

PURCHASES.

No. 24.—UNIVERSITY OF STRASBOURG.

AUSTRIA	5	14	0
DENMARK	5	12	0
ITALY	3	0	0
	14	6	0
AUSTRIA:			
COUNT HARRACH, Neuwelt, 2 glasses	0	4	0
LOBMEYR, Vienna, specimens of glass	5	10	0
	5	14	0
DENMARK:			
HOME INDUSTRY, fish scale embroidery, tools, carved wood	5	0	0
V. WENDRICH, Copenhagen, terra-cotta vase	0	12	0
	5	12	0

GERMAN EMPIRE.

No. 24.—University of Strasbourg—*cont.*

	£	s.	d.
ITALY:			
SALVIATI, Vienna, glass mosaic and beads - -	3	0	0

GIFTS.

No. 24.—UNIVERSITY OF STRASBOURG.

BOHEMIA:
HOFFMANN, Prague, gift of glasses, cut and frosted.

GERMAN EMPIRE:
GIFTS of DYES, COLORS and CHEMICALS.
From C. H. Du Bois, Hirschberg, Silesia.
„ Huquenel, Breslau.
„ Wetzel & Reissmann, Plugwitz, Leipzig.
„ Schering, Berlin.
„ Kungelmann, Dresden.
„ Gustav Dittler & Herbst, Hamburg.

PURCHASES.

No. 25.—MODELLIR SCHULE, DRESDEN.

	£	s.	d.
ITALY:			
BASSANO, Venice, glass beads - - - -	2	0	0
AUSTRIA:			
LOBMEYR, Vienna, specimens of glass - -	32	0	0
	34	0	0

PURCHASES.

No. 26.—HANAU MUSEUM.

	£	s.	d.
ITALY:			
MARCHESE GINORI, Doccia, vases and plaques -	16	8	4

PURCHASES.

No. 27.—LUBECK MUSEUM.

	£	s.	d.
DENMARK:			
GEO. HESSE, Copenhagen, 2 vases, terra-cotta -	3	0	0
P. IPSEN'S WIDOW, Copenhagen, 7 pieces, terra-cotta - - - - - - -	6	0	0
V. WENDRICH, Copenhagen, 3 pieces, terra-cotta -	2	8	0
	11	8	0

PURCHASES.

No. 28.—LEIPSIC MUSEUM.

	£	s.	d.
FRANCE:			
M. DECK, Paris - - - - -	4	0	0

PURCHASES.

No. 29.—OEFFENTLICHEN SAMMLUNGEN, STUTTGART.

FRANCE - - - - - - -	300	12	6
SPAIN - - - - - - -	50	0	0
RUSSIA - - - - - - -	76	0	0
DENMARK - - - - - - -	9	0	0
ITALY - - - - - - -	60	0	0
AUSTRIA - - - - - - -	112	6	0
GREAT BRITAIN - - - - -	280	18	0
	888	16	6
FRANCE:			
BARBEDIENNE, Paris, inkstand, vases, cups, &c. -	44	0	0
TH. DECK, assiettes and vases - - -	7	0	0
AUGUSTE LEMAIRE, bronze vase, polished - -	20	0	0
HENRY PERROT, 5 sets of inkstands and candle sticks, Louis XIV. and XV. - - -	168	0	0
GEOFFROY & Co., Gien, Italian pilgrim bottle, aiguière and plateau, Henri Deux - - -	6	0	0
CHRISTOFLE & Co., Paris, vase and plateau, bronze encrusted silver - - - - -	40	0	0
COLLINOT, Paris, jardinière, cloisonné enamel, cups and vases, cloisonné enamel on faïence - -	15	12	6
	300	12	6
SPAIN:			
TEODORO DE IBARZABAL, Guipuscoa, coffer, iron, repoussé, damascened, gold, and encrusted silver -	50	0	0
RUSSIA:			
A. POSTNIKOFF, Moscow, silver ware, 2 cups, 2 spoons, gilt and enamelled - - - - -	16	0	0
OFTSHINNIKOFF, Moscow, silver ware, 2 cups, gilt and enamelled, 1 cup, chased, cream jug, gilt and enamelled, sugar bowl, gilt, chased, and with landscape in niello, claret cup, cake box in imitation of bread, in gilt, with napkin in silver - - -	40	0	0
KHLEBNIKOFF, Moscow, silver ware, cups, cloisonné enamel, salt cellar mushrooms - - -	20	0	0
	76	0	0

GERMAN EMPIRE.

No. 29.—Oeffentlichen Sammlungen Stuttgart—*cont.*

	£	s.	d.
DENMARK:			
HOME INDUSTRY COLLECTION, fish scale embroidery, tools, carved work	5	0	0
MRS. SASSE, Copenhagen, embroidery	4	0	0
	9	0	0
ITALY:			
BAZZANTI, Florence, coffer, Florentine, mosaics	32	0	0
GINORI, MARCHESE, Doccia, 3 jardinières, maiolica, inkstand, and Capo-di-monte beer jug	28	0	0
	60	0	0
AUSTRIA:			
M. KLEIN, Vienna, leather-work	15	0	0
IGNAZ LUKSCH, Vienna, cups, ormolu "au mat," silver initials in bottom	8	0	0
AUGUST KLEIN, Vienna, albums, porte-monnaies and other objects in leather-work	89	6	0
	112	6	0
GREAT BRITAIN:			
ROYAL WORCESTER PORCELAIN WORKS	94	0	0
COPELAND & SONS, London, porcelain	9	4	0
ELKINGTON & Co., Birmingham, art-works in metal and electro	40	12	0
MINTONS, Stoke-on-Trent, porcelain	52	2	0
INDIAN DEPARTMENT, carved and inlaid wood, fabrics and metal work	85	0	0
	280	18	0

PURCHASES.

No. 30.—HAMBURG MUSEUM.

	£	s.	d.			
FRANCE:						
ROUDILLON, Paris, table, walnut, encrusted with pewter, and chair, red velvet seat, Henri Deux				58	8	4
AUSTRIA:						
LOBMEYR, Vienna, specimens of glass				25	0	0
GREAT BRITAIN:						
MINTONS, Stoke-on-Trent, porcelain	18	8	0			
INDIAN DEPARTMENT, arms, metal ware, jewellery, &c.	370	0	0			
				388	8	0
				471	16	4

PURCHASES.

GERMAN EMPIRE.

No. 31.—DARMSTADT MUSEUM.

	£	s.	d.
AUSTRIA:			
GRAF HARRACH - - - - -	3	0	0

PURCHASES.

GREAT BRITAIN.

No. 32.—EDINBURGH MUSEUM.

FRANCE - - - - - -	280	19	2
ITALY - - - - - -	80	0	0
AUSTRIA - - - - - -	20	0	0
GREAT BRITAIN - - - - -	723	11	0
	1,104	10	2
FRANCE:			
TH. DECK, Paris, plaque, lady, temp. Henri Deux, 2 plaques, 2 assiettes - - - - -	180	19	2
EMILE PHILIPPE, Paris, 3 bas-reliefs, "Diane de Poitiers," Rossi, Fontainebleau, "Nymph," Benvenuto Cellini, "Diana," Jean Goujon, all silver, snuff-box, oxidised. - - - - - -	22	0	0
AUBRY, Bellevue near Toul, 2 cornets, cylinders, sabot, Italian - - - - - -	1	0	0
BARBIZET, Paris, black bearing cachepot, portecarte two figures, Breton - - - - -	24	0	0
LÉON PARVILLÉE, Paris, plaque - - -	24	0	0
COLLINOT, Paris, faïence - - - -	12	0	0
LAURIN, Bourg-la-Reine, Seine, potiches and cache-pots - - - - - -	17	0	0
	280	19	2
ITALY:			
SALVIATI, Venice, glass mosaics and glass - -	80	0	0
AUSTRIA:			
ALOIS KLAMMERTH, Znaim, imitation maiolica, jugs, and "ringers" - - - - -	20	0	0
GREAT BRITAIN:			
COPELAND & SONS, London - - -	42	10	0
ROYAL WORCESTER PORCELAIN WORKS - -	50	0	0
WEDGWOOD & SON, Etruria - - -	58	17	0
ELKINGTON & Co., Birmingham - - -	175	0	0
MINTONS, Stoke-on-Trent - - - -	290	4	0
DOULTON & WATTS, London - - -	107	0	0
	723	11	0

ITALY.

PURCHASES.

No. 33.—MILAN MUSEUM.

	£	s.	d.
FRANCE:			
AUBRY, Bellevue near Toul 2 plaques, Italian faïence - - - - - - -	8	16	8
ITALY:			
BASSANO, Venice, 2 Venetian glass chandeliers, 6 arms for ditto - - - - - -	57	0	0
	65	16	8

PURCHASES.

No. 34.—INDUSTRIAL MUSEUM OF TURIN.

FRANCE:			
ALKER, AINÉ, 40, Rue Neuve des Petits Champs, Paris, sewing machines for button-holes - -	16	0	0

PURCHASES.

No. 35.—FLORENCE MUSEUM.

PORTUGAL:			
HENRI BURNAY, Lisbon, filigree silver, peasants' jewellery - - - - - - -	3	0	0

JAPAN.

PURCHASES.

No. 36.—YEDDO MUSEUM.

FRANCE - - - - - - - -	53	10	0
RUSSIA - - - - - - - -	18	10	0
ITALY - - - - - - - -	6	8	4
	78	8	4
FRANCE:			
M. DECK, Paris, jardinières, flaçons, cups, and bottles, faïence - - - - - - -	47	0	0
BRIANCHON, AINÉ, Paris, shell for cards, and 2 shells, porcelain ware - - - - -	2	10	0
SERGENT, Paris, candlestick, cachepot, Palissy ware -	0	10	0
JULES HOURY, Paris, plate, small vase, lamp, tile, Urbino borders - - - - -	3	10	0
	53	10	0

No. 36.—Yeddo Museum—*cont.* JAPAN.

	£	s.	d.
RUSSIA:			
CHOPIN, St. Petersburg, 2 bronze statuettes, huntsmen	15	0	0
KLEBNIKOFF, Moscow, 9 cups, gilt and chased	3	10	0
	18	10	0
ITALY:			
GINORI, Doccia, ewer and plateau, faïence	6	8	4

PURCHASES. RUSSIA.

No. 37.—MUSÉE IMPÉRIALE DE ST. PÉTERSBOURG.

FRANCE	56	6	8
PERSIA	40	0	0
PORTUGAL	11	0	0
DENMARK	10	0	0
ITALY	120	0	0
TURKEY	5	0	0
AUSTRIA	17	0	0
HUNGARY	50	0	0
GREAT BRITAIN	114	10	0
	423	16	8
FRANCE:			
TH. DECK, Paris, assiette, birds	6	0	0
GEOFFREY & Co., Gien, melonnière, tile enamelled, head in centre (blue), aiguière and plateau, maiolica with gilt handles, subjects "Our Saviour's Baptism," "the Woman of Samaria," Christ walking on the Waters," aiguière and plateau, Henri Deux, maiolica cup	19	4	2
BARBIZET, Paris, Pallisy ware, figure "Incroyable '93!"	20	0	0
SERJENT, Paris, coffer, Palissy ware, tile, relief, Old Rouen	5	10	0
JULES HOURY, Paris, appliqué, faïence, blue, relief copper, polished mounting, Renaissance, round plate	5	12	6
	56	6	8
PERSIA:			
"Hotam" lacquer works	40	0	0

RUSSIA.

No. 37.—Musée Impériale de St. Pétersbourg—*cont.*

	£	s.	d.
PORTUGAL:			
CERQUINHO Y SILVEIRA, Oporto, filigree jewellery, silver	6	0	0
HENRI BURNAY, Lisbon, filigree silver, peasants' jewellery	3	0	0
HENRI BURNAY, Lisbon, figures, coloured, types of national costumes	2	0	0
	11	0	0
DENMARK:			
GEO. HESSE, Copenhagen, 2 vases, terra-cotta	1	0	0
P. IPSEN'S WIDOW, Copenhagen, 2 vases, terra-cotta	5	0	0
V. WENDRICH, Copenhagen, 7 pieces, terra-cotta	4	0	0
	10	0	0
ITALY:			
CONSTANTINO CORTI, Milan, statue of Lucifer, red clay	120	0	0
TURKEY:			
30 pieces Pottery, different provinces of Empire	5	0	0
AUSTRIA:			
J. & L. LOBMEYR, Vienna, specimens of glass	10	0	0
ALOIS KLAMMERTH, Znaim, imitation maiolica, jugs, and "ringers"	7	0	0
	17	0	0
HUNGARY:			
N. LADANYI, Klausenburg, pottery	10	0	0
M. BORZY, Mezötur, stoneware	10	0	0
M. BIRO, Miskolcz, national dresses, &c. "Bèkes"	30	0	0
	50	0	0
GREAT BRITAIN:			
ROYAL WORCESTER PORCELAIN	21	3	0
JOHN MORTLOCK	21	15	0
A. B. DANIELL	45	18	0
COPELAND & SONS	12	0	0
MINTONS	5	14	0
INDIAN DEPARTMENT, pottery and metal wares	8	0	0
	114	10	0

No. 37.—Musée Impériale de St. Pétersbourg—*cont.* RUSSIA.

GIFTS.

INDIAN DEPARTMENT to the Agricultural Museum of St. Petersburg and Moscow, divisible into two complete series.

94 samples of grains, pulses, &c.
30 „ dyes.
20 „ spices.
38 „ oil seeds.
Collection of fibres.

PURCHASES.

No. 38.—MUSÉE DE MOSCOU.

	£	s.	d.
FRANCE	67	10	0
PERSIA	40	0	0
PORTUGAL	11	0	0
AUSTRIA	40	0	0
ITALY	6	8	4
HUNGARY	3	0	0
GREAT BRITAIN	6	6	0
	174	4	4

FRANCE:

BARBEDIENNE, Paris, vase, Persian, cloisonné enamel	7	16	8
GEOFFROY & Co., Gien, selections, Italian Gien, and Moustier faïence	6	16	8
POTTIER, Paris, cups, Limoges enamel	16	0	0
BARBIZET, Paris, Palissy ware, pair Spanish figures	3	4	2
BAGUES, Paris, aiguière and plates, copper, polished	33	12	6
	67	10	0

PERSIA:

Old drawing and other articles in lacquer ware - about	40	0	0

PORTUGAL:

CERQUINHO Y SILVEIRA, Oporto, silver filigree	6	0	0
HENRY BURNAY, Lisbon, silver filigree, peasants' jewellery	3	0	0
HENRY BURNAY, Lisbon, figures, types of national costumes	2	0	0
	11	0	0

AUSTRIA:

SCHREIBER & NEPHEWS, specimens of glass	10	0	0
LOBMEYR, Vienna, specimens of glass	30	0	0
	40	0	0

RUSSIA.

No. 38.—Musée de Moscou—*cont.*

	£	s.	d.
ITALY:			
GINORI, Doccia, 2 plates, maiolica, Italian metallic glaze - - - - - - -	6	8	4
HUNGARY:			
J. G. ZAHN, Zlatno, glass prismatic surfaces - -	3	0	0
GREAT BRITAIN:			
MINTONS, Stoke-on-Trent, selection of porcelain -	6	6	0

GIFTS.

No. 38.—Musée de Moscou.

INDIAN DEPARTMENT to the Agricultural Museum of St Petersburg and Moscow, divisible into two complete series.

94 samples of grains, pulses, &c.
30 „ dyes.
20 „ spices.
38. „ oil seeds.
Collection of fibres.

GIFT of glass from Schreiber & Nephews, about 25*l.*

PURCHASES.

No. 39.—Helsingfors Museum.

	£	s.	d.
GREAT BRITAIN:			
ELKINGTON & Co., Works of Art in electro deposit -	150	0	0
INDIAN DEPARTMENT:			
Pottery and woodwork - - - -	6	0	0
	156	0	0

SWEDEN.

PURCHASES.

No. 40.—Stockholm Museum.

	£	s.	d.
AUSTRIA:			
SCHREIBER & NEPHEWS, specimens of glass -	10	0	0

GIFT.

No. 40.—Stockholm Museum.

AUSTRIA:

GIFT from Schreiber & Nephews, specimens of glass, about 20*l.*

PURCHASES.

TURKEY.

No. 41.—CONSTANTINOPLE SCHOOL OF INDUSTRY.

	£	s.	d.
PORTUGAL:			
CERQUINHO Y SILVEIRA, Oporto, filigree jewellery -	5	0	0
HENRI BURNAY, Lisbon, silver filigree, peasants' jewellery - - - - - -	5	0	0
	10	0	0

PURCHASES.

UNITED STATES.

No. 42.—MASSACHUSETTS MUSEUM OF FINE ARTS, BOSTON.

	£	s.	d.
FRANCE - - - - - - -	35	0	0
DENMARK - - - - - -	18	16	0
GREAT BRITAIN - - - - -	42	0	0
	95	16	0
FRANCE:			
LÉON PARVILLÉE, Paris, 2 vases, Moresque patterns - - - - - -	35	0	0
DENMARK:			
S. HENRIQUEZ, Copenhagen, Parian figures - -	18	16	0
GREAT BRITAIN:			
MINTONS, Stoke-on-Trent, specimens of porcelain -	42	0	0
	95	16	0

PURCHASES.

No. 43.—CAROLINA MUSEUM.

	£	s.	d.
PORTUGAL:			
HENRI BURNAY, Lisbon, silver filigree, peasants' jewellery - - - - - - -	4	0	0

Unknown whether *North* or *South*; name of purchaser given—
PROFESSOR BECK.

GIFTS.

GERMAN EMPIRE.

No. 44.—FÖRST HOCH SCHULE, THARANDT, SAXONY.

Gift of INDIAN DEPARTMENT, 63 specimens Indian woods.

FRANCE.

No. 45.—FOREST SCHOOL AT NANCY, FRANCE.

Gift of INDIAN DEPARTMENT, 70 specimens Indian woods.

Museums. Names Unknown.

PURCHASES.

Museums.—Names Unknown.

	£	s.	d.
FRANCE - - - - - - - - -	15	0	2
DENMARK - - - - - - - -	5	0	0
ITALY - - - - - - - - -	32	0	0
PORTUGAL - - - - - - - -	5	0	0
	57	0	2

FRANCE:

Collinot, Paris, faïence - - - -	14	4	2
Brianchon, Ainé, Paris, porcelain nacré - -	0	16	0
	15	0	2

DENMARK:

Home Industry, fish-scale embroidery, wood carving, tools; all peasants' work - - - - -	5	0	0

ITALY:

Bassano, Venice, glass beads - - -	2	0	0
Salvo & Son, Genoa, silver filigree jewellery -	30	0	0
	32	0	0

PORTUGAL:

Cerquinho y Silveira, Lisbon, silver filigree jewellery - - - - - - - - -	5	0	0

APPENDIX D.

Showing the SALES made by each country to the MUSEUMS of EUROPE, ASIA, and AMERICA.

AUSTRIA.

	£	s.	d.	£	s.	d.
PORCELAIN, POTTERY, AND GLASS -	840	12	0			
LEATHER WORK AND FANCY WARE -	495	16	0			
				1,336	8	0

DENMARK.

PORCELAIN AND TERRA-COTTA - -	76	2	0			
HOME INDUSTRY, EMBROIDERIES, &c. -	29	0	0			
WIRE WORK - - - -	1	12	0			
JAPANNED WARE - - - -	1	18	0			
LEATHER WORK - - - -	3	10	0			
JEWELLERY - - - -	72	2	0			
				184	4	0

FRANCE.

TEXTILES - - - -	37	4	2			
MACHINERY - - - -	16	0	0			
WORKS OF ART IN METAL AND ENAMELS ON METAL - - - -	2,033	18	4			
ORNAMENTAL FURNITURE - -	431	16	8			
PORCELAIN, POTTERY, AND GLASS -	1,329	19	8			
				3,848	18	10

GERMAN EMPIRE.

PORCELAIN AND GLASS - - -	318	0	0			
JEWELLERY - - - -	11	4	0			
IRONWORK - - - -	1	0	0			
				329	12	0

GREAT BRITAIN.

PORCELAIN, POTTERY, AND GLASS -	1,618	3	0			
WORKS OF ART IN METAL WORK -	1,294	13	0			
				2,912	16	0

INDIAN DEPARTMENT.

POTTERY, METAL WARES, EMBROIDERY, JEWELLERY, FABRICS, CARVED AND INLAID WOOD AND ARMS -				821	0	0
Carried forward - -				£9,433	10	10

	£	s.	d.	£	s.	d.
GREECE.						
Brought forward -	-		-	9,433	10	10
Plastic Art - - - - -	600	0	0			
Jewellery and Costumes - -	85	0	0			
				685	0	0
HUNGARY.						
Pottery and Glass - - - -	96	0	0			
Costumes - - - -	55	0	0			
Woodwork and Parqueterie - -	30	0	0			
				181	0	0
ITALY.						
Mosaics, Glass, and Stone - -	548	0	0			
Bronze and Metal Work - -	445	8	0			
Jewellery - - - - -	445	4	2			
Statuary - - - -	120	0	0			
Porcelain and Faïence - -	248	15	10			
				1,807	8	0
MOROCCO.						
Jewellery, Timbuctoo Gold Work -	153	0	0			
Old Moorish Embroidery - - -	225	0	0			
Textiles - - - - - -	30	0	0			
				408	0	0
PERSIA.						
Drawings, Carpets, "Hotam" Work, Ancient Vases and "Curios" - - - -				2,104	0	0
PORTUGAL.						
Filigree Silver Work - - - -	91	0	0			
Plastic Arts - - - - -	10	0	0			
				101	0	0

Sales were made to museums of porcelain and faïence, but it was found impossible to obtain particulars.

RUSSIA.						
Metal Work, Silver, and Jewellery	629	12	0			
Bronze - - - - - -	121	0	0			
Glass - - - - - -	67	14	0			
				818	6	0
Carried forward - -				£15,538	4	10

	£	s.	d.	£	s.	d.
SPAIN.						
Brought forward -	-		-	15,538	4	10
LEATHER WORK - - - - -	105	0	0			
METAL WORK, IRON, AND STEEL -	799	0	0			
				904	0	0
SWEDEN.						
PORCELAIN AND MAIOLICA - - - -				3	0	0
SWITZERLAND.						
WOOD CARVINGS - - - - - -				30	0	
TURKEY.						
IRON WORK - - - - -	5	10	0			
CARPET - - - - - -	10	0	0			
WOODWORK, PAINTED - - -	10	10	0			
CLOTH WORK, MOSAIC - - -	25	0	0			
POTTERY - - - - -	13	0	0			
				64	0	0
Total - - - - -				£16,539	4	10

Sales were made of Maiolica and Faïence by Monaco, but no returns could be obtained.

SIR DIGBY WYATT.

CHARACTERISTIC FEATURES OF BUILDINGS.

On the most CHARACTERISTIC FEATURES of the BUILDINGS of the VIENNA EXHIBITION of 1873 as compared with the Buildings erected for previous International Exhibitions.—By SIR M. DIGBY WYATT, M.A., &c., Secretary to the Executive Committee of the Royal Commission for the Great Exhibition of 1851, &c.

Any building in which so vast, and complex an undertaking as an international exhibition must of necessity be in these days of almost universal rivalry, and competition, cannot but exhibit features of comparative excellence on the one hand, and defect on the other, before the great experiment of success, or the reverse can be brought to a fair issue. From obedience to such a law of necessity the buildings for the Vienna Exhibition could in no wise be expected to escape, since its unprecedented scales of magnitude, and importance could not fail to bring into the utmost prominence characteristics of either tendency. Before any such comparison can be instituted between attempts past and present, to work out satisfactorily problems common in scope, but varying in detail, as may justify our regarding special features of the present as helpful, or detrimental to results aimed at, we require to make ourselves acquainted with sundry experiences; firstly, for instance, with the latest set of buildings in their particulars; secondly, with the buildings of the past in their general aspect; thirdly, with what may appear to have tended to excellence in the past; and fourthly, with what may appear to have caused defect in the past. From such data, justly appreciated, we may arrive at a fair estimate of—fifthly, what may appear to have chiefly promoted success in the present, and hopeful prospects in the immediate future; sixthly, at what may appear to have most detracted from thoroughly happy issues in the past, and from hopes of the same in the future. Of course conclusions arrived at under our third and fourth heads should form the best tests for correct judgment under our fifth, and sixth. Hence mainly the value (if we should be fortunate enough to derive any from the attempt at analysis) of the inquiry which has been instituted by the Royal Commissioners on the present occasion.

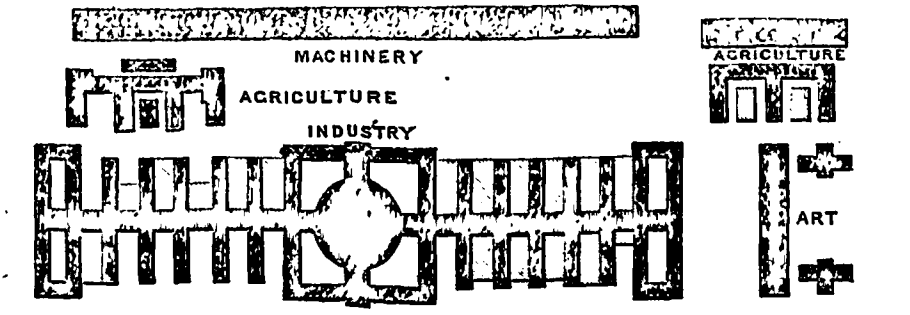
It must be borne in mind that the matter under consideration is the relative merit of various exhibition-

buildings, and excludes altogether discussion of what others may probably treat with useful results—the general principles of management applicable to international exhibitions of art, and industry as illustrated by Viennese experience.

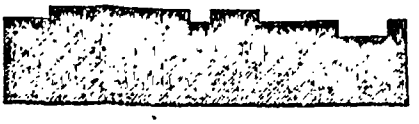
It is inevitable that in discussing relative merit the critic, aiming at making his labour practically useful in any way, cannot with propriety altogether refrain from pointing out relative demerit, especially where demerit in principle may appear to have magnified demerit in result; but the author would have it clearly understood that no one can be more keenly alive than he is to the intensely difficult task which those set themselves, who take upon their shoulders the material responsibilities, and difficulties which follow, and surround the organisation of international industrial exhibitions. From one point of view, of course, those difficulties increase in the ratio of the magnitude of the enterprise, and this is especially the case with reference to the buildings; but by way of compensation there attaches to the march of every colossal undertaking, when once fairly started, a sort of momentum which crushes opposition, engages sympathy, and not unfrequently commands success.

A.—Our interest appears to lie firstly with the present set of buildings in their particulars.

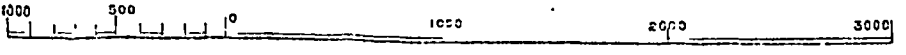
Our Crystal Palace in Hyde Park made, as an absolute novelty and surprise in 1851, an indelible impression on the minds of all who saw it. In endeavouring to realise what the Exhibition of Vienna may have lately been we may therefore well apply, for the information of Englishmen, the main dimensions of the first-named building as a scale of parts. It covered a parallelogram, it may be remembered, about 1,851 feet long by about 450 feet broad, or rather less than 810,000 feet superficial after deducting certain places left uncovered for the preservation of old trees. The main building at Vienna, as originally constructed for the reception of specimens of current products only, and exclusive of varieties of machinery, agriculture, art, archæology, and hundreds of other miscellaneous specialties, covered an area larger than that which afforded accommodation for every class of industry exhibited under cover in 1851; but as increased by various additions, formed by covering over internal courtyards previous to the opening of the exhibition, the total available area was increased to 1½ times that at first enclosed in the main building. The relative extent of the London, 1851, and Viennese, 1873, Industrial Exhibitions is shown by the annexed diagram:—



PLAN OF VIENNA EXHIBITION.



PLAN OF 1851 EXHIBITION.



SCALE OF FEET.

The great gallery prepared for the reception of machinery in motion at Vienna gave accommodation for four times as much upon the level of the ground as was available for what seemed so overwhelming in intricacy, and quantity when we first saw it in Hyde Park; so all great marvels grow, the giant of less than a century old often seems but the pigmy born yesterday, to have run a hundred years ago is but to crawl to-day, and no more forcible illustration could probably be cited of the rate at which men's minds expand in the nineteenth century with regard to material things, than the fact that such monster conceptions as that of Vienna should have been dreamt of as practicable; unless indeed it be the still more startling circumstance that any such conceptions should ever have reached the stage of realisation. No wonder that half the world seemed unwilling to credit, when only promised, what the imagination almost refuses to depict now that the promise has been more than realised.

The grounds which contained the exhibition with its outbuildings were situated in the Lower Prater, the favourite playground of Vienna, between the "Haupt Allée," and the Danube, and formed an area of over five-and-twenty million square feet, of which amount the buildings alone comprised an area of about one and a quarter million square feet, exclusive of covered passages and courts.

The chief buildings forming the exhibition were, firstly, the Palace of Industry, or great hall for miscellaneous manufactures; secondly, the Fine Arts gallery; thirdly, the Machinery department; fourthly, the Agricultural department; and, fifthly, the various other outbuildings overwhelming in number and extent.

To properly understand the setting out of the exhibition, the reader should refer frequently to the plan which accompanies this report, while he reads the following description:—

The hall of industry consisted of a nave running nearly east, and west from end to end of the buildings, 2,953 feet long, 82 feet 10 inches wide, and 22 feet 6 inches high. In the middle of this nave was the great feature of the building, the domed rotunda, 354 feet in diameter, round which ran a circular passage about half the width of the nave. This nave, like the spine of a human being, had ribs running at right angles to its length, which ribs, or side halls, 32 in number, were 246 feet 3 inches in length from their junction with the nave to their outer faces; the end pairs of halls being joined together, forming effective architectural features.

The four courts, or halls next the rotunda, two on either side, were also joined together by courts of the same length as themselves, thus forming a square 676 feet across, round the rotunda, or central feature. Opposite the middle of the southern side of this square was the principal entrance, with gardens, and fountains on either side. The courts were apportioned to the several countries according to their geographical position east or west of Austria, those to the west being to the left of the central block, and those to the east on the right. On passing up the principal entrance, or transept running from south to north, the countries furthest west, for instance, the United States, Brazil, and South America, were at the extreme left; then came Great Britain; then Portugal and Spain, and so on, till at the extreme right were presented the exhibits of Japan, China, and Siam.

Owing to the swampy nature of the soil on which the exhibition buildings had to be erected, and the difficulties of drainage, the only alternatives open to the architects were a very strong foundation of concrete, or a temporary one of wooden piling. The former was adopted under the dome and chief entrance, and all parts intended to be permanent erections; and piles about 12 feet long under those portions which were to come down at the close of the exhibition, and also under the flooring in general. The piles which had to carry walls were placed at intervals of about 5 feet 6 inches apart; under each roof-bearing column of the nave there

were six piles, and under those of the side courts four piles. All the piles were driven in by hand, bearing testimony to the spungy nature of the soil.

It was originally intended that the walls of the main building should be of wood framing filled in with brickwork, but, for many good reasons, it was ultimately determined to use light wrought ironwork instead of wood, and brickwork plastered on both sides as described in detail further on.

The iron supports, or stancheons, which carried the roof trusses in the side courts were upright lattice girders 3′ 3⅜″ deep from out to out; the web of ¼″ metal, and the flanges formed of two angle irons 3½″ × 3½″ × ⅜″. The foot of each of these stancheons rested on an iron plate 3′ 11¼″ × 11¾′ cast on the upper side with a lip 1¼″ wide which fitted round the bottom flange of the stancheon. These cast iron plates, in their turn, rested on the four piles above-mentioned. At the upper extremity of the stancheon was a wrought iron plate 7½″ × ⅜″, which separated it from the continuous bent girder forming the roof truss, and the upper flange of the stancheon. This plate, and the starting flange of the roof truss were firmly rivetted together. The roof truss, which was also a lattice girder, and of the same width as the stancheon, was segmental shaped with a radius of 33 feet 9¾ inches to the "intrados," and 35 feet 7½ inches to the "extrados." To the upper side of this girder angle pieces 3½″ × 3½″ × ⅜″ were rivetted to take the wooden purlins on which was nailed the boarding to carry sheets of zinc.

The supports, and roof trusses of the nave were similar to those of the side courts. The girders were 4 feet 7¼ inches deep from "out to out." The radius to the bottom of the roof truss was 62 feet 2½ inches, and to its upper edge 61 feet 2⅜ inches, the centre from which the upper flange was struck being a little more than 6 feet above that from which the inner flange was turned.

The roof trusses had stancheons to carry them in all cases except where the side courts opened into the nave, and in these cases the roof trusses rested on girders, which themselves rested on the L-shaped stancheons formed by the junction of the nave, and side court stancheons, and were further strengthened by stout wooden framing.

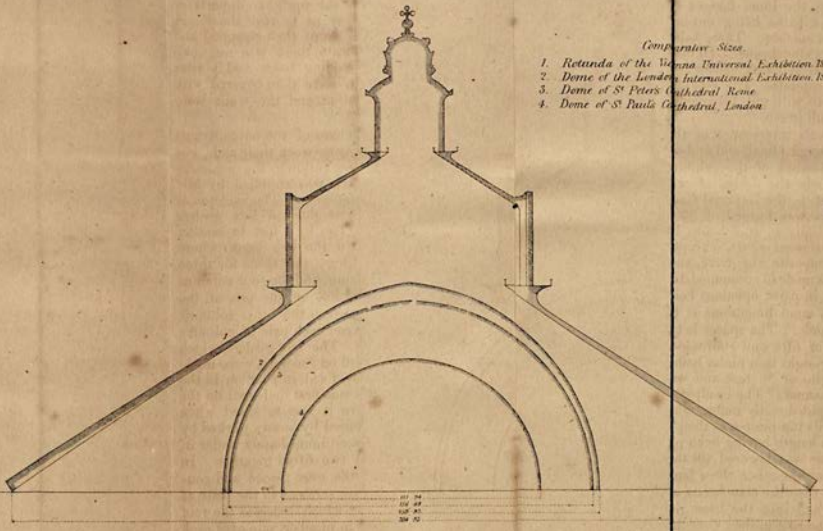
The outer flanges of the stancheons were embedded in brickwork, 1 foot thick to the side courts, and 1 foot 6 inches thick to the nave. This brickwork was plastered both outside and in, and was decorated as subsequently described. The side courts were lit by 26 windows, thirteen on each side, 10′ 10″ high, 13′ 9″ wide, and 5′ 3″ apart from each other. The nave had 5 windows on each side, 15′ 1″ high

by 16′ 1″ wide, in the space (114 feet) between one side court and the next one to it. In no case was any part of the buildings lit by skylights, but always by windows.

Whatever may have been the original idea of decorating the iron stancheons, it was rendered impossible of execution by an unforeseen occurrence. The outer flanges of the stancheons being as before remarked embedded in brickwork, were bound to give way more or less as the brickwork settled down, and some method had to be devised to cover this subsidence. Solid balks of timber, circular in section, were fixed against the inner flanges of the upright supports, so much of the balks being cut away as to rest the flange against a flat surface. These balks were then strapped and bolted to the stancheons. To decorate these was an obviously natural, and easy matter by adding bases and plaster ornamental capitals. The columns were then covered with crimson cloth with gilt ornamentation, and the walls were painted a dull green.

In the exact intersection of the axes of the naves, transverse, and longitudinal, and mid-way between their ends, was the great feature of the exhibition building, the conically roofed rotunda, the design of which was supplied by Mr. Scott Russell to the Imperial Commission. The skeleton of this rotunda was formed of 32 wrought-iron box girders placed vertically as stancheons 10 feet by 4 feet in section at equal distances apart, except in the two cases where they came opposite the nave, and here the space for three columns was made to accommodate four, and the four columns were joined in pairs, openings being left on the axis of the nave of the same dimensions as between the other columns of the rotunda. The spaces between each pair of columns were used for lifts and staircases. The box girders which rested on wrought iron plates bedded on concrete, were made in five lengths of 20 feet and were fixed in position in the following manner. The headpiece was first delivered on the works and put directly under where it was to stand when finished; this top piece was then raised by screws worked by hand, and a length having been placed immediately under it, the top piece was lowered till the two fitted together. In the same way the other three lengths were placed and connected, and then the stancheons were screwed to the plate at their feet, and into the base ring which received the roof girders. The roof girders were 30 in number, one over each stancheon except where the coupled piers occurred opposite the nave, and in these cases the girders came over the openings. The roof was formed at a pitch, or angle of slightly over 30 degrees in continuous boiler plate rivetted

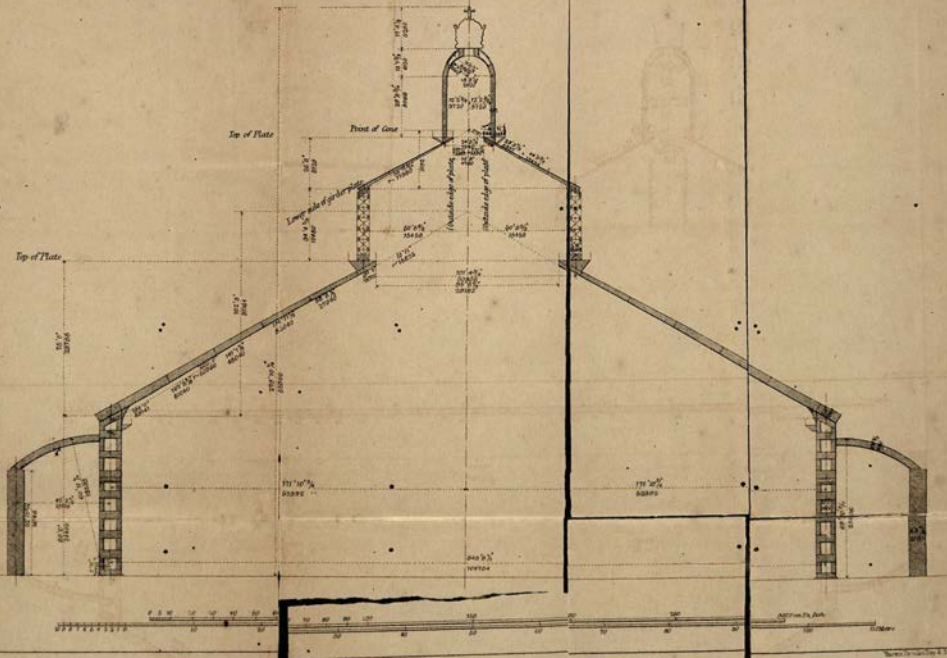
VIENNA UNIVERSAL EXHIBITION. 1873.

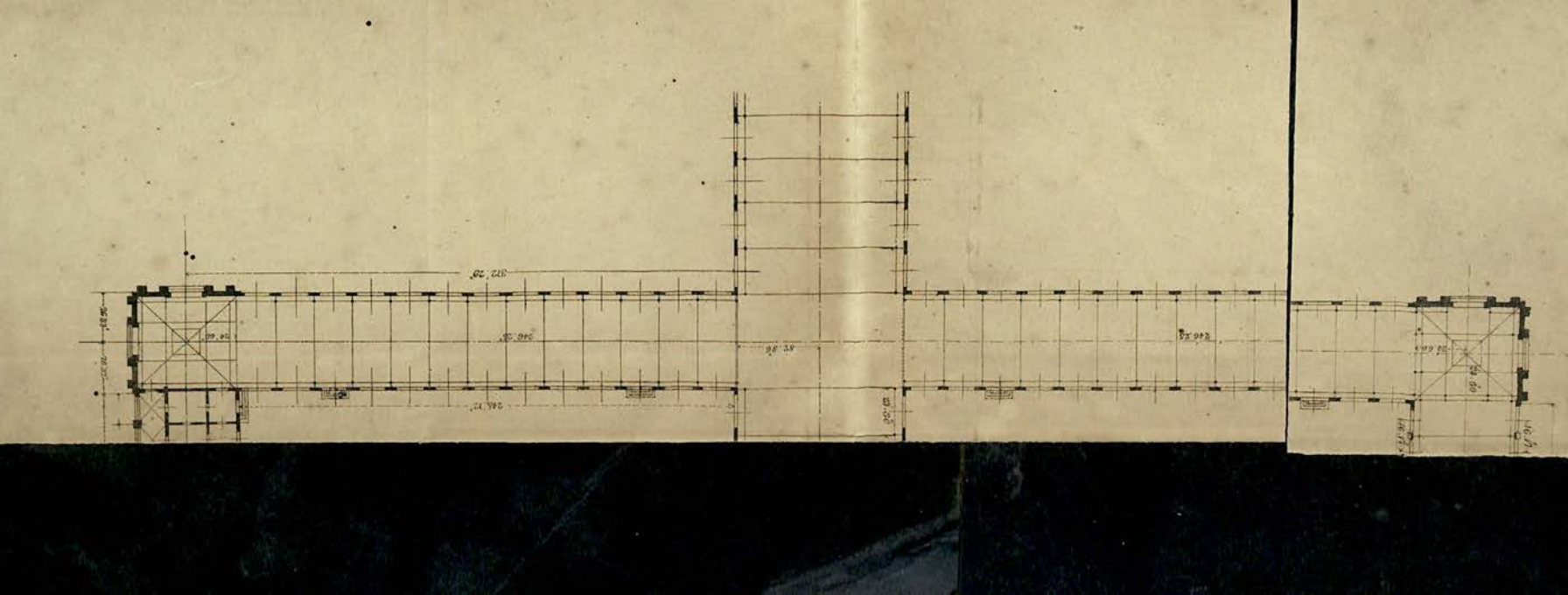


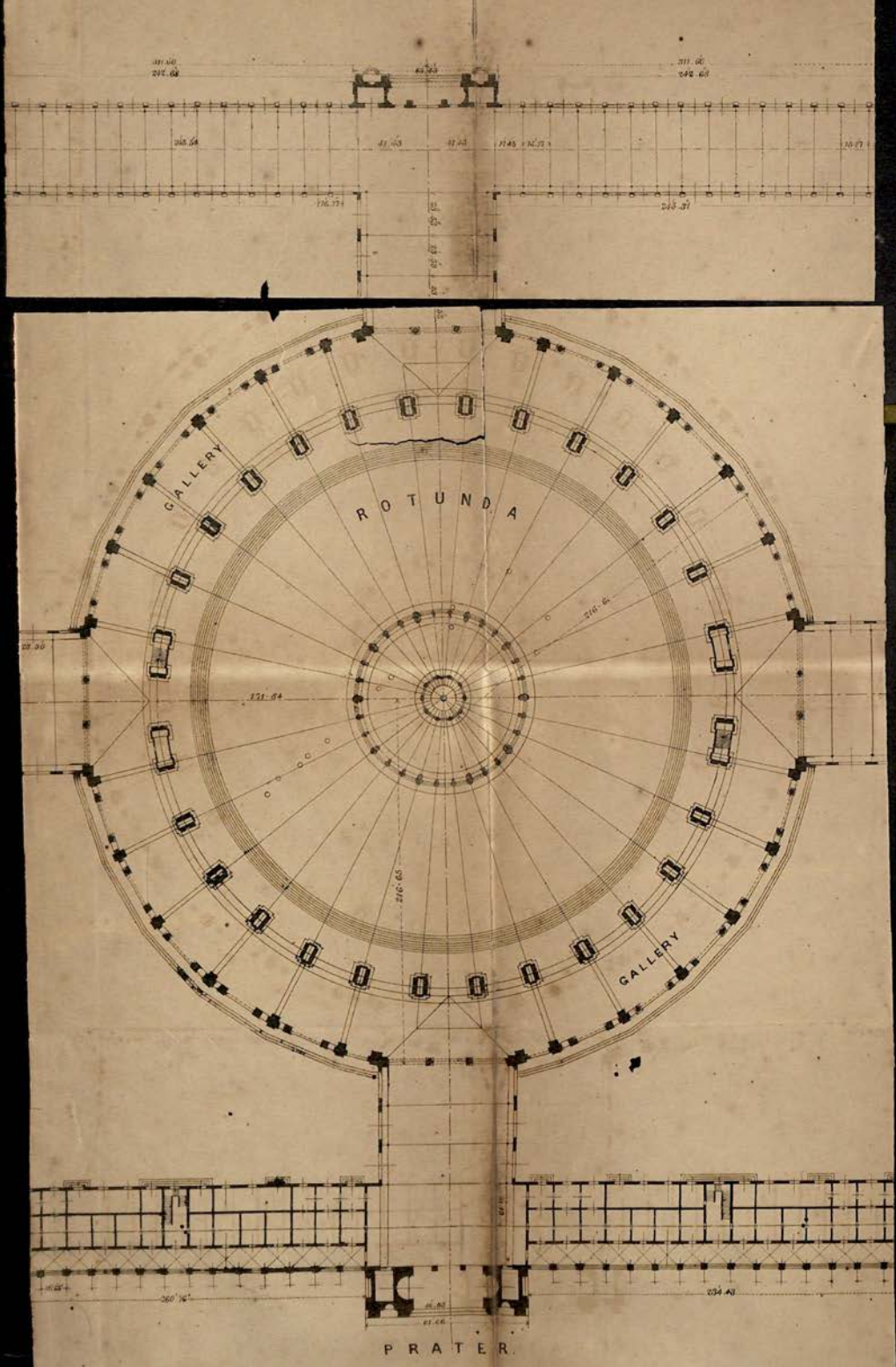
Comparative Sizes.

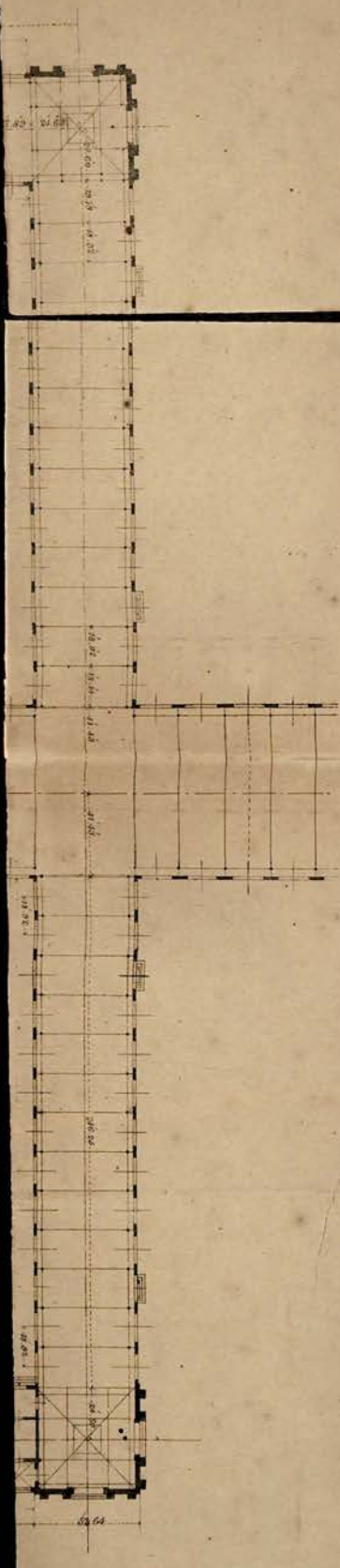
1. *Rotunda of the Vienna Universal Exhibition 1873.*
2. *Dome of the London International Exhibition 1862*
3. *Dome of St Peters Cathedral Rome*
4. *Dome of St Pauls Cathedral London*

THE VIENNA UNIVERSAL EXHIBITION; SECTION THROUGH THE CENTRAL ROTUNDA.






GALLERY
ROTUNDA
GALLERY
PRATER



Vincent Brooks, Day & Son, Lith.

to the bottom flanges of the great radial roof girders and purlins, keeping them in place, and was carried up from the base ring until the diameter of the circle formed by the upper ends of the roof girders equalled 100 feet, when another ring was fixed to the upper ends of these girders. Into this ring 30 iron stancheons were fitted similar to, but smaller than those forming the great rotunda below, and a cylindrical lantern 30 feet high was thus formed. This was again roofed similarly to the larger conical zone below until the diameter at the top of these roof girders was reduced to 30 feet. On this was another lantern 30 feet high which was surmounted by an enlarged copy of the crown of Austria formed of wrought iron plate with masterly dexterity by the national workmen.

The rotunda was divided into five stories or tiers for decoration. At the ground story the upright iron box girders were cased in a wooden framing, and were then plastered. That portion facing inwards was decorated with Corinthian pilasters having moulded enriched panels projecting slightly from the general face, and running up to the under side of the cornice which separated the first from the second tier of decoration. This cornice was made of zinc sheeting on a framework of iron which formed a gallery, running completely round the rotunda. Above the cornice at the commencement of the second tier, was a large ornamental cove, and over this the conical roof which was covered with canvas, stretched as a velarium, over the whole of its under surface.

This canvas was divided into thirty equal parts corresponding to the spaces between the iron ribs in the roof, and each compartment was decorated with borderings, and an angel 21 feet long in the centre, painted in oil. The third tier of ornament consisted of the lower lantern, the 30 semicircular headed windows in which were divided into 10 groups of 3, each third space being marked with a pilaster; above this were a cornice, and velarium, similar to those of the larger conical roof below, but the ornamentation was simpler, and no figure subject was introduced in the centre.

The last tier of ornaments consisted of the top lantern light, which had a domical roof. The whole was elaborately picked out in gold and neutral colours. On the ground tier that side of each pier facing its neighbour had two Doric panelled, and enriched pilasters, from the upper sides of whose capitals were turned arches, the keystone of these arches apparently carrying the cornice which really rested on the backing behind the Corinthian capitals before-mentioned. The only exception to this series of arches going all round the rotunda was where the double girders occurred. These

spaces were used as staircases and lifts, and had open metal grilles on the face. The floor of the rotunda was lower than that of the general building, and in the exact centre was a highly ornamental fountain which added greatly to the general effect of the grouping.

Externally, the building seen from the front was composed of a central block, and two symmetrical wings, all in the Italian Renaissance style after the manner of Palladio. This central block again was composed of three parts, a centre, and two wings. The middle of the central block, forming the grand entrance, was very similar to a triumphal arch, with a great arch in the centre, flanked on either side by a pair of Corinthian pilasters, between which were a pedimented niche, a band carved in figure subjects, and medallions of the Emperor and Empress. These pilasters supported a regular cornice with frieze, and over this was a sculptured attic dying against a segmental pediment.

The wings of the central block consisted of an arcading with ornamental frieze, and cornice over. At the end of these wings were small pavilions with a repetition of the central feature on a smaller scale, having a curved zinc roof with louvre top, and a flagstaff.

The nave and side courts of the Industrial Hall, which composed the wings of the building, were Renaissance in character. The ends of the side courts which were advanced nearly to the face of the block, had a large arch turned in the centre, and a plain classic window on each side, with Composite pilasters between the three openings, and at the angles. The sills of the windows on the return faces of these side courts formed a bold string course all round the building, which served as the springing line of the large arch. These windows were divided from each other by piers with angle pilasters, and enriched panels, which carried an enriched frieze, and from which started the roof of these courts. This frieze was returned round the nave, where it came immediately under the sills of the windows which were divided from each other in the same way as those of the side courts, and which also had an enriched frieze similar in idea to that of the side courts. Between the enriched band under the sills of the nave windows, and the string-course at a lower level, was a series of ornamental panels. The two end courts on each side of, and furthest from the central block being united, served to accentuate the angles of the building in a sensible, and picturesque manner by being made into two pavilions with arcading between similar to that of the central block. The side of the building externally presented an appearance resembling that of the

central block on the Prater front, with a central feature rising, as in the front, abruptly above the arcading of the wings, and with pavilions at the outer extremities of the wings corresponding with those in the front central block. The central feature of the sides had a segmental pediment, and consisted of four pilasters in pairs, having a large opening in the middle which broke into the cornice, and which was coved inwards. Between each pair of pilasters were a pedimented niche, and medallion of the sovereign. Above all the building, seen from almost every direction, towered the gigantic conical dome, which was treated externally as simply as possible. The upper part of the rotunda showed itself above the top of the roof of the circular alley of the main structure which surrounded it, and this lower roof was made to have the appearance of a continuous abutment to the great cone. Where the wall of the rotunda appeared it was divided into thirty parts corresponding with the girders in the conical roof, and under each girder was placed a pilaster, and between the pilasters were formed rectangular panels. The girders of the conical roof of the rotunda were left exposed externally, as were also those of the lower lantern.

The lantern was treated externally much in the same way as it was internally; being divided into thirty semi-circular headed arches grouped in triplets divided by piers carrying a cornice, and balustrading. The top lantern had semi-circular headed windows separated by attached columns, and these carried a cornice from which started a domed roof, and at the summit of the dome was, as has been already stated, a gigantic copy of the Austrian Imperial crown in wrought-iron plate, inlaid with glass imitations of the crown jewels.

The Fine Arts Gallery situated to the east of the Industrial Hall, from which it was disconnected except by two galleries of communication, was a brick building covered with cement, about 650 feet long, and 115 feet wide, and divided into two blocks by a central hall. In the northern block were exhibited the works lent by artists of western Europe, and in the southern block those by Austrian, Hungarian, and German artists; America and Greece were accommodated at the southern corner of this block. As this space was too small to contain all the Fine Art work contributed, there were two other buildings in the Fine Art group connected with the chief Fine Arts Gallery by covered passages, containing sculpture. That to the north contained the works from Italy, and that to the south those

from northern Europe. The arrangements for lighting the pictures, contrived with great care by Herr Hasenauer, were most successful. To the extreme east looking on to the Heustadtl Canal was a triumphal arch of good and rich design.

The Machinery department, situated on the north of the Exhibition grounds nearest the Danube, was 2,615 feet long by 164 feet wide. This splendid building, covering an area of about 428,860 feet, was composed of a nave with an aisle on both sides, from which it was separated by strong brick piers, and from its vast size and simplicity furnished a fine illustration of the "lamp of power" in architecture.

The aisles were one story buildings 28 feet wide and 17 feet high, having a lean-to roof resting against the walls of the nave, which rose to a height of 43 feet to the under side of the roof, far above the aisles. The nave was a building 91 feet 10 inches wide having perfectly plain square piers, and segmental arches to the ground story, between which piers there were in all cases openings into the aisles: above was a series of square piers with simple capping, between which were windows occupying the full height of the opening, and having their sills above the top of the lean-to roofs of the aisles; on the top of [illegible] piers was a continuous plate on which rested the lower [illegible] of the ordinary iron trusses which carried the boarding with its zinc covering to keep out the wet. The nave, which occupied 240,000 square feet, was used for machinery in motion, and the aisles, as a rule, for machinery at rest. The countries in this, and in the Agricultural Department were situated according to their position, as nearly opposite their allotments in the Industrial Hall as could well be managed.

The Agricultural Department was divided into two distinct sections, one at the west of the grounds, and the other at the extreme north-east. The latter about 250,000 feet in superficial area, was occupied by Austro-Hungary, Germany, and Russia; and the western Agricultural Hall, containing about 176,500 superficial feet in area, accommodating other exhibiting countries. These buildings were of rough woodwork, resting on a pile foundation, well designed, and answering their purpose efficiently. The wood framing was covered on the outside with overlapping board, and the roof was merely boarded, and felted.

The planning, and decoration of the whole of the Exhibition buildings were confided to a committee of architects at the head of whom was Herr Hasenauer of Vienna, to whom much praise is due for the skill and talent which he so thoughtfully brought to bear on the difficult work entrusted

to him. The engineering work was designed by Herren Engerth, and Schmidt, with the exception of the design for the dome introduced to the commissioners by Mr. Scott Russell, and which in some respects corresponded in general principle of construction, though varied in dimension, with some of the designs, and working drawings prepared by the building committee of the Exhibition of 1851 and their officers, but set aside upon that occasion to make way for Sir Joseph Paxton's brilliant novelty. The whole of the ironwork, and fixing of this great feature were supplied by Herr Harkert of Westphalia, who, with his able practical engineer, Herr Steiger, reserved to himself the right, which he certainly unsparingly used, to modify many important elements in the method, and scheme of its construction as proposed by Mr. Russell. Scattered over the grounds which contained the chief structures composing the Vienna Exhibition were numerous outbuildings for various purposes. The most essential of these for use if not for effect was the water tower to the west of the British portion of the Agricultural Hall which rose to a height of 143 feet. The reservoir itself 25 feet in diameter, and nearly 21 feet deep was capable of containing about 10,000 cubic feet, or over 60,000 gallons of water, and was carried on hollow cast iron columns resting on a foundation of brickwork. This tower supplied 100,000 gallons of water every hour for fountains, waterclosets, and other purposes of the Exhibition. As many of these buildings constituted some of the signal successes of the Exhibition, further notice of them may be best relegated to the section of this report embodying certain views upon that portion of our subject.

B.—Secondly, the buildings of the past in their general aspect.

The precursors in remote periods of International Exhibitions in recent times were the annual fairs held formerly in many places at home and abroad, where producers and buyers were brought together at fixed periods, in order to avoid having to travel, at various seasons, for different objects and materials, to foreign, and frequently distant and uncivilized lands, with the possibility, or rather probability, that the purchaser, on arriving at the end of his outward journey, might find that his outlay and risk in travelling,—the latter no slight matter in days gone by—had been to no purpose, and that his time and energy had been wasted. Middle men or tradesmen were few and far between until the Italians ofganized a complete commercial system ;

and it was not till the end of the 13th century, at the commencement of the break up of serfdom, and vassalage, and possibly with the advent of the spirit of travel promoted by the Crusades, that fairs, where men of one nation flocked to buy the produce of another nation, were of common occurrence. Local fairs, in connexion with fête days of patron saints, were of course always common, and many such still exist, but of the great International fairs there are now only two or three remaining, the best known of which are those of Leipsic and Nijni Novgorod. Licence to hold annual fairs at Easter and Michaelmas was granted by the Emperors to the town of Leipsic as early as the 12th century; a third annual fair at each new year was commenced in 1458 at the same place, and the three fairs in each year were sanctioned by the emperor in 1508. The fairs at Leipsic are held partly in a permanent building called Auerbach's House, and partly in other buildings, some permanent and some temporary. The fair now held at Nijni Novgorod, which lasts nearly two months in the year, was instituted as late as 1648 at Makarieff, during which early period the fair lasted only five days. In 1691 foreigners had further facilities granted to them, and the result was that the fair so increased in size that a great wooden building was erected capable of accommodating 800 shops in the year 1750. This building having in course of time also proved too small, a new building, also of wood, was put up in 1809, capable of making up 1,400 shops. This building in its turn proved too small, almost as soon as it was built, and 1,800 sheds were erected round the main block. In 1816 all the buildings forming the bazaar at Makarieff were destroyed by fire, and the site of the fair was removed to Nijni Novgorod. Permanent buildings were here erected containing over 2,500 shops in 48 blocks, all covered with iron, and the open galleries of communication, supported by iron columns, were also roofed with iron. From such fairs, which were little else than improvised towns with streets, and shops for temporary occupation only, to International Exhibitions, several stages had to be passed, the two most prominent being official, and non-official National Exhibitions. Of the latter class, the only three worthy of note are: 1stly, One held at Leyden in 1699, chiefly of curiosities; 2ndly, One projected at the Château of St. Cloud in 1797, to show the works of the Government manufactories of Sèvres, the Gobelins, and the Savonnerie; and 3rdly, The exhibition started at the Maison d'Orsay, No. 667, Rue de Varennes, by the Marquis d'Avèze, to see if his idea would be taken up at all by the

chief manufacturers of France. This exhibition contained only objects fitted for the use and amusements of the upper classes, but it proved so successful that the French Government, at the instance of Napoléon, decreed the first official exhibition in the Champs de Mars, which consisted of temporary buildings, a large temple in the middle, and 60 porticoes round it. It remained open daily the three last days of the year, to show the works of its 110 exhibitors. The attempt having proved successful, far beyond the hopes of the most sanguine, the Government decreed that a National Exhibition should be held annually, but during the change of Government which occurred at this period, from the Directory to the Consulate, the idea was temporarily lost, and it was not till 1801 that the second official French Exhibition took place. It was also held in temporary buildings in the quadrangle of the Louvre, and 229 exhibitors showed the state of industry in its various branches at that time practised in France. The third French official exhibition in 1802 was also held in the Louvre quadrangle, with space for 540 exhibitors. The fourth official exhibition was held in a building erected on the esplanade of the Hôtel des Invalides; there were 1,422 exhibitors. The fifth official exhibition was held in 1819 in temporary buildings in the court of the Louvre, with 1,662 exhibitors; and in the same locality were held the sixth and seventh exhibitions, in 1823 and 1827, with 1,648 and 1,795 exhibitors respectively; the building in the latter year being considerably larger than on former occasions. The eighth exhibition was held in 1834 in four pavilions erected on four sides of the Place de la Concorde; the number of exhibitors was 2,447. The ninth exhibition, held in 1839, was held in the Carré de Marigny of the Champs Elysées, and covered an area of 177,530 square feet, affording accommodation to 3,281 exhibitors. The exhibition building was composed of a gallery and long apartments, and a separate building for the exclusive exhibition of the products of Mulhausen. The tenth official National Exhibition was held in 1844 in the same locality in a temporary building, a parallelogram in plan, 645 feet long by half that length wide. On the axis of its width were two out buildings joined on to the main erection, to accommodate the jury, and to contain the royal and official apartments. These buildings, covering altogether an area of 211,000 feet, were finished in the short space of 70 days, and afforded room for 3,960 exhibitors. The eleventh and last of the great official, and purely national French exhibitions was held in

1849 in the Champs Elysées, in a temporary building 705 feet long by 327 feet wide, exclusive of the building for live stock, which was 358 feet by 102 feet, and the office. The whole occupied an area of over 280,000 feet, and afforded accommodation for 4,494 exhibitors. While these exhibitions were being held in France, other foreign countries were not idle; for instance, national exhibitions were held at Ghent in 1820, Tournay in 1824, Haarlem in 1825, and in 1830 at Brussels for the products of the industry of the Netherlands; and later in 1835 and 1841 at the last-named city, for the productions of the industry of Belgium, after that country had obtained its independence.

In Prussia exhibitions were held at Berlin in the years 1822 and 1827, where 176 and 208 exhibitors respectively showed the state of manufactures in the then smallest of the five great powers of Europe. Local German exhibitions were held almost every year from that date, at one time at Berlin, at another time at Cologne, or Düsseldorf, or Breslau, up to the great German exhibition in 1844, when 3,040 exhibitors from various parts of Austria, Prussia, and the other German states displayed at Berlin the advance of industry up to that date. The erection to hold these exhibitors consisted of two buildings joined together, the one 288 German feet and the other 293 feet long, both of them 84 feet wide. These buildings contained on the two stories of which they were composed 68,660 German superficial feet of exhibiting space.

In England we were somewhat slow at following the example set us by our neighbours, but in 1828 George IV. patronized an attempt to hold an exhibition in the Royal Mews, Charing Cross, London. This experiment, repeated on several occasions, failed of finding public favour, and was abandoned in the year 1833 on the proximate pulling down of the building in which it had been tried. Subsequently the Society of Arts took up the subject, and it was under its auspices that the public were educated to demand what they had previously regarded with at least semi-aversion. An industrial exhibition held in Bingley House, Birmingham, in 1849, was the immediate, and fairly successful precursor of the great effort about to be mentioned.

We now come to the first of the exhibitions distinguished from its predecessors by being International instead of being confined to the produce of the country in which the exposition happened to be held.

The report to Her Majesty on the opening of the exhibition of 1851, stated that a building "entirely novel in its

" construction, covering a space of more than 18 acres, " measuring 1,851 feet in length, and 456 feet in extreme " breadth, capable of containing 40,000 visitors, and affording " a frontage for the exhibition of goods to the extent of more " than ten miles," had been erected within the short period of seven months, viz., between the 26th of September 1850 and the 1st of May 1851. The contractors bound themselves on pain of forfeiture to remove the buildings entirely within six months. The exhibition closed on the 15th of October 1851, produced 505,000*l.* and left a surplus of about 150,000*l.* The building cost 193,168*l.* 10*s.* 2*d.* from which 33,250*l.* were recovered under the head of old materials after removal. The iron and glass of which it was composed, and the framing and design, it is needless to write about to Englishmen as the tale could be but a "thrice told" one, and most of us are acquainted with so much of the building as still exists on its present site at Sydenham. The number of exhibitors was 13,937, and the total number of paying visitors was 6,039,195. Such were the leading features of our great achievement in the origination of International Exhibitions, and on these we refrain from dilating as others may have already done so "ad nauseam." The great novelty of, and the exhausting labour involved in the 1851 experiment served as checks to any immediate successor, and it was not until the year 1855 that the next International Exhibition was held in Paris.

In the meanwhile however two National Exhibitions were held at Cork in 1852, and at Dublin in 1853.* Both were fairly successful, and earned laurels for architects and builder, in the persons of Sir Thomas Dean, Sir John Benson, and Mr. William Dargan. The Cork building run up in the rear of the corn market although successful was comparatively unimportant constructionally, but that at Dublin on the lawn of the Royal Dublin Society was in many respects effective; especially in its fine central hall, 425 feet long, 100 broad, and 104 high, and kept mainly free for promenade, ceremonial and music: its attractions mainly saved the undertaking from financial failure.

In 1853 an International Exhibition was held in New York which, through the non-completion of the building till long after the announced opening day, turned out a commercial failure. The building similar in idea to our Crystal Palace of 1851, with nave and transepts, but with a large dome at the crossing, was constructed entirely of iron and glass.

* The Exhibition at Dublin in 1853, like that of New York, was International.

In 1854 a German exhibition was held at Munich in a building erected for the purpose, also of iron and glass, 850 feet long, and 85 high in the nave. This edifice designed by Herr Voit is still in existence.

In 1857 there was a fine art exhibition at Manchester which was very successful through its precious contents; but its building offered little occasion for remark, being fairly well adapted for its own special purpose but unsuitable for displaying an International Exhibition.

Whereas in the Hyde Park exhibition of 1851, the fine arts (with the exception of sculpture) were almost entirely conspicuous by their absence, in the second universal exhibition, held at Paris in 1855, Prince Napoléon in his address to the Emperor on occasion of the opening ceremony on the 15th of May of that year, observed,—"we [the French] have "followed our neighbours, and allies who have had the glory "of the first attempt; we have completed it by an appeal to "the fine arts"; and by this supplemental aid alone was this exhibition rendered as successful, or rather as little disastrous as it proved. The cost of the building and attendant expenditure was little if at all short of a million sterling, and the receipts were 117,666*l.* 15*s.* 0*d.* The number of exhibitors was 20,839, just half as many more as exhibited in London in 1851, and the paying visitors were 4,533,464, of whom one-fifth visited the galleries of fine art and the remainder the industrial section. The total number of visitors it will be seen on comparing the figures, was only three-quarters as many as visited the London Exhibition. The buildings composing this second International Exhibition were situated in the Champs Elysées and were to some extent predetermined for permanence, but through subsequent alterations in the arrangements partly, tacked on to the original scheme in so hasty a way as to receive construction only of a light and temporary nature.

The great main building subsequently used as the Palais de l'Industrie, was already in progress at the time when the Government took up the scheme of the first Paris International Exposition. As such it was the property of a company, the interest on whose outlay was partly guaranteed by the French Government; and this mingling of Government with private enterprise very much affected the disposition and assets of the exhibition. This building, a parallelogram on plan, was placed due east, and west, and contained the various exhibits from all countries, with the exception of the specimens of fine arts, machinery, agriculture, and an infinite number of miscellanea which were in separate buildings. To the south

of this chief building was a large rotunda which contained furniture, and musical instruments, and at the southern end of this a passage led to the long machinery gallery which stretched south-west and north-east. Opposite the western point of this machinery building was the Palais des Beaux Arts, where were exhibited paintings, sculpture and drawings. Agricultural implements were in a separate building to the south of the Palais de l'Industrie, and west of the rotunda. The control employed in arranging the exhibits in countries and groups was of a weak and vague description, indeed one might almost say there was no precise and reliable arrangement at all. The products of all kinds however were so beautiful and interesting, and so much taste was exhibited in their grouping and arrangement, that to the thoughtful student this exhibition proved one of the most important from an educational point of view of any which has as yet taken place.

The Italians were not long behind-hand, considering how recently they had established themselves as a united kingdom, since in 1861 a National Exhibition was held at Florence, in a building cleverly adapted for the required purpose. The old railway station, built in 1849 from designs by Brunel, assisted by T. H. Wyatt, late President of the Royal Institute of British Architects, had become disused on the concentration of all the Tuscan metropolitan stations at Florence, in the neighbourhood of Sta. Maria Novella; and was converted by suitable additions into a very fair exhibition building two stories high, the lower one containing the industrial, and the upper the art exposition. There were separate buildings for machinery, agriculture, and zoology.

The third great International Exhibition was held in London in 1862, on the site of some parts of the present annual International Exhibition buildings at South Kensington, and on the large area on which a vast gallery for specimens of Natural History is now in process of erection. Obviously intended for a permanent structure, much of the exhibition building was built of brickwork with strong iron columns bedded on York stone, on brick and concrete foundations. The total area roofed in was 988,000 square feet, or 60,000,000 of cubic feet, and the floor space available for the 26,348 exhibitors was about a million and a quarter square feet. The main building, it may be remembered, was a parallelogram on plan fronting the Cromwell Road, about 1,150 feet long by 560 feet wide, with two arms stretching northwards towards the park, the eastern half being occupied by Great Britain and its colonies, and the western half by foreign countries. The eastern arm, the

prolongation of the north-east transept, was used for the show of agriculture, mining, and food collections, and refreshment rooms; while the western arm, occupying the corresponding position on the north-west transept, accommodated the machinery in motion and refreshment rooms. The northern ends of these two arms were joined by arcades cleverly and economically constructed by Captain Fowke, quadrant shaped on plan, which led into the conservatory of the Horticultural Society, whose grounds were enclosed by the various exhibition buildings.

The main building was in two stories, the one next to the Cromwell Road being devoted to the fine arts. It must still be in every one's recollection that the fronts of this building were of brickwork, with a tower at each end, and a central mass in the middle of each of the three fronts. The prominent characteristics of the building were the domes, and picture galleries. The domes, two in number, one on the axis of each transept, composed of iron and glass, 160 feet diameter, rose to a height of 200 feet, and were crowned with ornamental finials 55 feet high. Their design reflected the greatest credit on the ingenuity, and daring of Captain Fowke, and their building by Messrs. Kelk, and Lucas was a splendid "tour de force." The picture galleries were economically another great success for Captain Fowke; the light coming from above the bold coved cornice showed off the paintings to great advantage, and if the buildings had only been treated in as architectural a manner as they had been well studied from a utilitarian point of view, there is little doubt that they would have been appreciated by the public as they deserved to be for their economic merits. Unfortunately, however, money running rather short their fitting decoration had to be postponed; and visitors often left the building, feeling that when once out of the picture galleries there was something more wanting for effect than that building supplied; to the educated eye it was clear that what was missing was a freer scope given to the master eye, and hand of the properly trained architect and ornamentist. To this want was probably due the ultimate condemnation of the buildings, and the transfer of the materials to Muswell Hill.

The fourth great International Exhibition, the last of note prior to that of Vienna, was held at Paris in 1867, in temporary buildings in the Champs de Mars. The grounds in which the building stood had the advantage of reaching to the River Seine close to the bridge of Jena, and so afforded the best possible accommodation for marine and hydraulic exhibits. The main building of the 1867 exhibition was

almost elliptic on plan; more exactly it consisted of two semicircles, the broad ends opposite each other separated by a parallelogram 1,240 feet long by 360 feet wide, the longer side of which was of the same size as, and parallel to, the diameter of the semicircles. Each country exhibiting had a slice of this ellipse allotted to it, but the relative positions of the countries were not quite regular. This exhibition was arranged rather according to subjects than in geographical order. In the centre was a small ellipse laid out as an open garden; around this an elliptical court, containing exhibits of antiques and other works, showed for the first time in International Exhibitions the "history of labour" from a remote date to the commencement of the 18th century. Beyond this, the ellipse continuing to expand as it removed from the centre, was appropriated as an extensive gallery of fine art; beyond this again stretched concentrically the court or alley for showing the application of the liberal arts; then the court for furniture of various kinds; then attire; beyond this products of mining industry; and lastly, in the outermost part of the great ellipse, was exhibited machinery, at rest, and in motion. The agricultural portion of the exhibition was here, as in all other cases, in a separate building from all other objects shown.

The main building having from the outset proved far too small to accommodate all the exhibitors, numerous outbuildings were erected in the various parts of the grounds comprised within the external enclosure around the exhibition palace, to receive what could not so well be placed in the main building. In former exhibitions various countries had had separate portions allotted to them, as was the case in this exhibition, but on no prior occasion had any clear division, on the basis of classification by materials, been carried out, even if suggested. As may have been recognised on reading our preceding description of the Vienna Exhibition building, the arrangement adopted at Paris in 1867 was altogether thrown over in 1873, and the method of division at Vienna was fundamentally geographical instead of industrial. The area occupied by the main central building at Paris covered over 1,650,000 feet, and afforded accommodation to 50,226 exhibitors; the number of paying visitors admitted was 9,921,698. The cost, greatly augmented by the adoption of the curvilinear plan, was enormous.

During the interval between the exhibition of 1867 and that of Vienna, there have been many minor local and general exhibitions, the most noteworthy being that of the Central Union of the Fine Arts applied to Industry, held in Paris in 1869, in the old Palais de l'Exposition in the

Champs Elysées; that of Dublin recently, and that of Leeds (a purely fine art and loan collection exhibition, after the model of the great Manchester experiment in 1857), held in a large hospital not too well adapted for its temporary purpose.

C.—Thirdly, those buildings in the past which appear to have most tended to excellence.

In striving to discriminate between the excellencies of past exhibition buildings, and their defects, we may do well to endeavour to trace what was retained, and what discarded from time to time in process of arriving at the present comparatively efficient state of International Exhibitions, dwelling more especially upon those of 1851, 1867, and 1873, in which years certainly the greatest efforts were made to achieve success. That a well arranged exhibition will *cæteris paribus* prove more valuable as an object of study than an ill arranged one is evident for more than one reason. In the first place visitors may be spared the necessity of having their attention diverted from the products of industry in order to constantly refer to maps or plans, often unintelligible, seldom quite correct, to find the object they may wish to see, in a building arranged on some definite system, be that system the best or not; in the second place, where there is no order, it becomes difficult for the jury to carry in their minds, still more difficult for the general public to weigh, the comparative excellencies, and relative improvements of one class of exhibits of any country over the same class of some other nation; and in the third place, where objects are scattered about in such confusion that one group may be in a main building and another group of the same class, perhaps too of the same country, may be in a detached building, possibly many hundred yards away from that with which it ought to be in immediate connexion, it becomes a matter of almost impossibility not to omit seeing some portion of that class without reference to which a just impression of the whole matter cannot be derived. That a properly constructed exhibition building, that is one well suited to its intended purpose, possesses extraordinary advantages over a building unsuitably designed or used for a purpose for which it was not originally intended, I would refer to the experience of any one who visited the Exhibition of 1855 in Paris, and of 1851 in England. But beyond that the very fact that a temporary building should be designed with cheap materials, so that the outlay or loss for dead stock or building might be reduced to a minimum, must be clear to every thinking mind. Our two English exhibitions of 1851 and 1862 afford the best examples of comparison for this, the immense loss on

the last named contrasting very unfavourably with the relatively slight loss on the building of 1851. The latter was perhaps a little too temporary in its character, and perhaps a little too cheap; while the former was built too evidently perhaps for permanency without satisfactory assurance of that very requisite condition before excessive cost was incurred.

At the outset, as has been remarked in the preceding section, exhibitions were not held in grand expressly made buildings, but were simply agglomerations of separate shops, or booths very much as in an ordinary fair. Where these assemblies were held at considerable intervals, either temporary buildings were erected or some already existing construction was made to do temporary duty as a fair; but where these shows were held annually, or oftener, as at Makarieff and Leipsic, permanent buildings were erected, and these in their turn were supplemented by temporary structures at very full gatherings. The very building a permanent erection of some kind suited to the purpose was a great step in advance, and concurrently with this progress in respect to fairs, especially international ones, we must also trace the advance of exhibitions for the show of industrial or art progress, as distinct from the show of goods at fairs merely for the purpose of sale or barter. Exhibitions simply for display and comparison were first of all held in buildings erected for entirely different purposes. As has been before stated, the earliest French exhibitions were accommodated in the apartments of the Château of St. Cloud, and in those of the Maison d'Orsay, the various objects being placed in different chambers, just as they are arranged at the present time in the Cluny Museum, without any special reference to classes, materials, or species. The next step in advance was the provision of purposely erected temporary groups of buildings, such as those erected in the court of the Louvre. At this stage tolerably sized rooms were obtained, and goods exhibited without the thereby necessary displacement of the articles which previously, and usually occupied their places; better access and smoother locomotion in the building were the results of this advance. The French exhibition of 1839 was about the best example of national exhibition buildings of this class. This consisted of one large gallery and eight long apartments, besides a separate detached building admitting of tolerable classification. The last and greatest step on the road to exhibition buildings as they should be was the provision of sufficient cubical space in one great chamber, capable of subdivision as necessity might demand, and elastic within the limits of its total area. The French exhibition

buildings of 1844 and 1849 were built on this principle, and the opinions arrived at, after careful consideration of these plans, and the necessities of the case, by the Commissioners of the 1851 Exhibition, as seen by what they decided upon as the leading points of desirability with regard to the then novel proposal of a universal exhibition, show that these erections of 1844 and 1849 marked a sensible advance towards ultimate success in exhibition buildings.

The features which chiefly made the exhibition of 1849 a success were the extreme liberality with which the arrangements were conducted, from the building itself, with its wide gangways and abundant light, to the attendants, who were numerous and intelligent. As there was only one entrance for the public under constant supervision, there was little chance of the accounts going wrong so far as receipts were concerned, and default was reduced to a minimum. On the other hand, numerous exits gave ready means of leaving the building in case of great crowds, or in the possible event of fire or other accidents. The wide gangways too served to allow people to stand still, and admire what took their fancy without incommoding others who desired to circulate. In all previous exhibitions, which were much smaller than this of 1849, objects had been arranged more or less in groups, but on this occasion two difficulties presented themselves and occasioned much trouble; the first was the state of political ferment at that time in France, which rendered it doubtful, till the last moment almost, if the exhibition would be held at all; and the second difficulty was that the number of exhibits had so largely increased from the original scheme that it was no longer feasible to arrange in classes the various articles sent in by nearly 4,500 exhibitors. This exhibition was also grievously affected by the habitual want of punctuality on the part of both exhibitors, and authorities, from which no succeeding exposition has as yet apparently been able to altogether free itself.

The Royal Commissioners for advising as to what was requisite for the exhibition of 1851, under the carefully elaborated advice of a singularly able building committee, consisting of William Cubitt, Charles Barry, Robert Stephenson, Isambard Brunel, Robert Cockerell, and T. L. Donaldson, in asking for designs in competition stated that due regard should always be had to, and that success in a great measure depended on,—

1st. A due regard being paid to the provisional nature of the building.

2nd. The advisability of constructing it (when its removal after the close of an exhibition is predetermined), as far as

possible in such, a form or forms as to be available, with least sacrifice of labour and material, for other purposes so soon as its original one should have been fulfilled, thus ensuring a minimum ultimate cost.

3rd. Extreme simplicity and repetition of parts demanded by the short time in which such work is always required to be completed. Rapidity up to a certain rate being always a means of economy in construction. In the arrangements of the plan to rely for effect on economy of construction, vastness of dimension, and fitness of each part to its end, instead of upon great elaboration.

4th. Economy of construction both of materials and labour to be always studied.

5th. The provision of facilities for the reception, classification, and display of goods to be ensured.

6th. Facilities for the circulation of visitors never to be infringed.

7th. Arrangements to be provided for keeping grand points of view uninterrupted.

8th. Centralisation of supervision to be studied, for security and automatic working.

9th. Some striking feature should always exemplify the current, and most advanced state of the science of construction in the country inviting exhibitors.

10th. Economy in the planning of the structure is best attained by doing away with internal walls (all divisions being made by the necessary stalls), so as to reduce the main construction to columns supporting the lightest form of weather-tight roof in long unbroken lines, and by the whole of the work being done in the simplest manner of ordinary, and easily obtained materials, and as adapted in all respects to serve ultimately for ordinary commercial, or current purposes.

11th. To ensure facilities for the reception, classification, and display of goods, by placing the main central entrance or entrances for the reception of objects for exhibition, at the spot, or spots most readily approachable from the direction in which the goods would be most easily brought to the building.

12. To bear in mind that all cases accompanying goods require to be examined, registered, catalogued, &c. in the offices of the executive, which should be so placed as to be useful both during the preparation for, and the subsequent duration of the exhibition. The packing cases to be speedily shipped to trucks running on a line of rails laid down temporarily, and conveyed to the central turn table, from which they may be carried by lines of rails at right angles

to the first, to that portion of the building in which they may be destined to be finally placed. Bye passes to be provided at intervals to prevent a whole line being blocked by temporary breakdowns.

13th. The most important condition to ensure successful classification is that those, to whom the duty of arrangement may be confided, should be hampered by no fixed limits of space, such as are always present when the building is divided into a number of halls, sections, or chambers.

14th. The successful display of the goods is always best insured by leaving, under certain general restrictions, the fitting up of each stall to the exhibitor or his agent, floor space only being allotted to each; and stands, frames, brackets, shelves, &c. being put up by a contractor's carpenter, at a fixed tariff.

15th. The maximum of light should usually be provided in this country, as it is easy to reduce it, but all but impossible to increase it; and the most economical wall space may be furnished by connecting pillar to pillar transversely, by beams or rods, from or against which flat wall-space, draperies, &c., may be cheaply and strongly suspended or fixed.

16th. Facilities for the circulation of visitors are best attained by suggesting, not dictating, the most desirable paths to be followed. The main current of visitors should be induced to pass in one direction, but secondary parallel gangways should allow impatient visitors to make their way very rapidly from one end of the building to the other, so that those, who may find any great central gangway at all blocked up, may be able to get on without pushing or jostling others.

17th. Numerous doors of egress should afford ready means of exit for a large number of persons. Seats should be provided in abundance for those who may desire to rest, but in positions where they do not impede circulation.

18th. Arrangements for keeping grand points of view uninterrupted tend to beauty of effect, and quiet, while for certain ceremonies they are indispensable. Uninterrupted views from or, to the main centres greatly assist the visitor in finding his way, and learning his lesson.

19th. The seats, and main avenues should be so arranged, that on the occasion of the distribution of the prizes, or other fêtes, immense numbers of persons may be accommodated with good views of what may be passing.

20th. The current business of the exhibition should be carried on in one spot, and be readily under control, so that representatives of the controllers, and principal direction, clerks, accountants, police, firemen, &c., should be kept near

together. Telegraphic correspondence should bring each of the pay places into communication with the accountant's office, and with the police.

It was by a strict observation of most of these rules (the building committee's plan in all its main features having been retained although its mode of construction was altered to the Paxton system) that much of the success achieved by the exhibition of 1851 was attained; and subsequent experience in all succeeding exhibitions has tended to confirm the general accuracy and propriety of the conclusions then arrived at.

Although it is undeniable that the ingenuity, brightness, and entire novelty of the glass palace took the whole world by storm, and earned for England a veritable triumph, there were yet many features about the structure upon which, prior to Sir Joseph Paxton's apparition, the building committee of the Royal Commission had determined, worthy of juster and more favourable consideration than they received while men's eyes were dazzled by the brilliant success of the original Crystal Palace. The elementary idea of the building committee having been directed to the provision of such buildings as should find (after having served for exhibition purposes) the best and readiest market for railway purposes as serving for second rate stations throughout the country for which at that period there existed an almost insatiable demand, would no doubt have found for the Royal Commissioners after the close of the exhibition a much more profitable market for the used up structure than they met with in the persons of the promoters of the present Crystal Palace Company. The merits also of the central feature, or rotunda with its domical or conical roof, 200 feet in diameter, on the design of which the great engineers upon the Royal Commission bestowed great labour in conjunction with the architects, may surely now be recognised since the realisation of a somewhat similar conical roof, upon a somewhat similar system of construction, and upon an even more stupendous scale than was contemplated by its projectors, has become at Vienna an accomplished fact, through the energy and clear sightedness of Mr. Scott Russell, who thoroughly appreciated the building committee's design.

It is not in a report intended for unprofessional readers that the differences of proposed details of construction between the building committee's designs, and the roof covering of the Vienna rotunda as executed can be insisted upon, but the design of the great engineers would apparently have been quite free from the paucity of central light which detracted to some extent from the full success of the splendid

experiment in the Prater. The retention of the metal covering above instead of below the reticulation of radiating iron beams and concentric purlins, would have also tended to obviate the inconvenience and load which may hereafter perhaps result from piled up snow.

Still under all circumstances, and with any drawbacks, it must be satisfactory to all who respected the great talents and skill of men such as Cubitt, Brunel, Stephenson, and Charles Heard Wild, to find a palpable demonstration, upon a scale even half as large again as that they contemplated, of the practical sufficiency, and applicability of modes of construction analogous to those devised by those eminent men. The merits of their views with respect to their proposed rotunda at the date at which they were propounded, were unfortunately insufficiently recognised for their reputations.

After the year 1851 the glass palace mode of construction renewed its successes (and also it must be admitted some of its drawbacks) both at home and abroad in many striking structures—from the English Crystal Palace at Sydenham, where much of Paxton's original building was re-erected under his own personal superintendence, to the Amsterdam Paleis van Volksvliet and the Munich Glas Palast, which both did duty as industrial exhibitions upon a vast scale.

In all buildings which, like the original model of 1851, were inclosed by glass walls as well as glass roofs, the charm of an almost superabundance of light was indulged in; but to this many practical objections presented themselves in sufficient force and number to lead to the adoption of more common modes of building on recurrences of International Exhibitions. Thus, on the next occasion at Paris in 1855, when a new building became requisite, although much glass was still retained, both in the roof, and in large, and numerous vertical windows, a permanent stone structure, with constructional features in brick and iron, was erected in the Champs Elysées, not ill-adapted, in many respects, for its purpose. It exhibited a handsome architectural aspect, which still adds its decorative effect to that of the foliage of that beautiful park, and still continues, in sound repair, to subserve many useful purposes from time to time, with good results to the population of Paris and to many foreign lovers of art. Its chief practical drawback was the gloom which reigned on the ground floor, under its somewhat too abundant galleries. Still it was very handsome internally, and looked particularly well on occasion of the many stately fêtes which were held in it under the Second Empire.

When we again brought the moving "citizens of the

world" together in 1862, we departed much further from the transparent type of the Crystal Palace towards usual and permanent structure. The great and most successful feature of that exhibition was the addition of art to the attractions of industry. As picture galleries the noble halls of the Cromwell Road were admirable, although they failed to enlist sufficient sympathy from the public to encourage the Royal Commissioners to attempt that permanent retention for which their solid construction had obviously intended them. The enormous domes of the Palace of Industry had been certainly marvels of difficulty overcome in rapid, and ingenious construction, but they, too, failed to receive any sufficient measure of admiration. The mode of lighting of the main hall, which chiefly depended upon a series of vertical lights from a sort of clerestory, was not altogether agreeable, causing shadows from objects placed in the main nave, neither favourable to those objects nor beneficial to others withdrawn from the direct rays of light passing through the windows. The roof, in spite of its very clever design by Captain Fowke, and brilliant decoration by Mr. Crace, would, from its complete opacity, exhibit a tendency to descend; and few, therefore, mourned when it was ultimately decided to carry off the great domes, and most of the roof trusses, and other materials, to contribute to the erection of the building which met its untimely fate on Muswell Hill—the more regretted, perhaps, from improvements in design in many respects introduced by the excellent taste, and architectural knowledge of Mr. Johnson.

The chief success of the latest International Exhibition previous to that of Vienna, held at Paris in the year 1867 on the Champ de Mars, was due to the gaiety which reigned around it, rather than to the merits of the main Palais de l'Industrie. It was interesting enough to contrast in one's mind's eye the plenitude of success which seemed to mark and accentuate the acme of power reached by the nephew, the second Napoléon, upon the very same spot upon which the triumphs of his uncle had been crowned, on the occasion of his institution of the first official exposition held in France.

At the end of the year 1797, on the return of Napoléon I. from the successful termination of the Italian wars, peace and its arts were universally demanded on the part of the nation; and as eager to triumph in this department as he had shown himself to be in its opposite, the great general at once determined that Industry should have its ovation, as War had already achieved its triumph. On the same spot in the Champ de Mars on which the army had celebrated

the inauguration of the noble collection of Italian spoils, and but six weeks after that fête, the nation erected the "Temple of Industry," and exhibited specimens of the blessings and advantages of peace. The temple stood in the midst, while around it were arranged sixty porticoes, filled with all that Paris, and its vicinity could produce, either of use or beauty. The galleries remained open only during the three last complementary days of the year VI. of the Republic, 1798, but excited the greatest enthusiasm throughout the country. So it certainly was on the occasion of the opening of the Exposition of 1867 under Napoleon III., who must then with proud eyes have recognised the zeal and promptitude with which not only his European, but even some of his Oriental contemporaries seemed to strive who should most distinguish themselves in his eyes, and those of France generally. It was in the outlying buildings in the grounds of the Exposition that this eagerness was most aptly and successfully displayed. In the handsome volume by M. Normand "L'Architecture des nations étrangères, étude sur les prin-" cipales constructions du Parc à l'Exposition Universelle " de Paris, 1867," the architecture of foreign countries there represented, and comprising works from Egypt, Morocco, and Tunis, and the wooden constructions of Russia, Austria, the Tyrol, Sweden, Switzerland, &c., found fitting illustration in 75 large architectural plates. These buildings were for the most part carried out upon a grand scale, and in the case of Russia and Egypt especially, offered singularly interesting and novel materials for the study of the arts of construction, many of them available as suggestive of sensible modifications in the class of structure now under discussion.

D.—Fourthly, the greatest Drawbacks to Structural Excellence in the Past.

The principle of the fair, or collection of temporary buildings or booths, to which I have alluded as characteristic of all the early exhibitions of industry, was of course defective, being insecure both by day and by night; and wanting altogether in protection from the weather, for the visitors walking or loitering in the alleys, as well as generally, to a great extent, from defective construction, for the goods stored in the booths, as may be seen to perfection in any Dutch "kermesse." An improvement was of course effected when the collocation of the temporary buildings within some inclosing permanent structure, as in the case of the early French exhibitions held within the courtyard of the Louvre, afforded to the temporary buildings very considerable defence from sudden gusts of wind, and such vicissi-

tudes of weather. Others of the early exhibitions were held either wholly, or partly in buildings of an altogether permanent character, as in the Château of St. Cloud and the Maison d'Orsay at Paris, or the Royal Dublin Society and Bingley House, Birmingham, in Great Britain, but in all cases with defective grouping, owing to the inelasticity of the buildings, setting classification at defiance. The defects resulting from trying to make goods fit buildings, instead of buildings to fit goods, led at length to the habit of constructing temporary buildings upon a large scale, with the special view of properly exhibiting the series of products relied upon from intending exhibitors—in fact, by degrees a due system of pre-arrangement was organised, with which special buildings, although of a temporary character, were made to harmonise. To a certain extent, care and forethought began to take the place of accident. The tentative steps in this direction long continued, however, very defective, and so it was that of the series of structures raised at large cost on the Carré Marigny of the Champs Elysées in 1839, 1844, and 1849 for national expositions, none were entirely satisfactory, or really established models of importance for the subsequent and greatly extended experiments of holding international exhibitions.

Thus it was that when the Royal Commissioners for the Exhibition of 1851 (the first of the international series) set themselves to investigate what precedents they should aim at repeating, and what avoiding, they encountered far more of the latter than of the former. Their immediate experience was based on the then last held French exposition of 1849, and on that occasion they recognised an entire absence of effect, owing to the cutting up of the plan of the buildings into chambers, and galleries, one or two of which could only be seen at the same time, so that no unity of effect or sense or grandeur could be at any time perceived. The products on that occasion were in many respects admirable, but the mode of exhibiting them most defective. Arrangement, and classification were faulty alike in the building, and the catalogue of its contents. A want of punctuality in the completion of the building, and in the reception of products marred everything, and neither Mr. Cole nor I, who had hurried from England together, to observe how "such things were managed "in France," will probably ever forget the chaos we encountered on the day fixed for the opening. Method there was little or none, and considerable and unseemly confusion was created by the many who persevered in endeavouring to follow the series presented by the catalogue, meeting others endeavouring to adhere to a reasonable comparison of ana-

logous products. One up, and one down current met in the gangways, and much confusion ensued. We felt that it would have been well to have let the numbers of the catalogue follow each other alternately on both the right, and left-hand sides of the gangways, and so to have encouraged the whole stream of visitors to pour in one direction, instead of to meet, and so block up the passages, and paths between the left-hand side stalls, and those upon the right.

One of the most striking defects in the plan of the building was the total impossibility of converting it, for any great national purpose, into a vast hall in which a multitude might assemble to witness such an exhibition as the bestowal of the prizes. In no position could more than a fourth of the whole extent be seen at one view, so that not only was the effect of a possible *ensemble* entirely lost, but the agreeable effect of an impression of grandeur, and unity on entering was perfectly sacrificed to a fancied regularity of plan.

One peculiarity, which architecturally was certainly distressing, was that a system of sham seemed to preside over all the ornaments and construction. Great *carton pierre* trusses which supported nothing, painted bas-reliefs to imitate bronze, fir covered all over with block-printed paper to make it look like oak, were all unnecessary items of expense. If each simple material had been allowed to tell its own tale, and the lines of the construction so arranged as to conduce to a sentiment of quiet, with simple repetitions of simple forms, the qualities of "power" and "truth," which its very considerable extent must have necessarily ensured, could have scarcely failed to excite admiration of the building, and that at a very considerable saving.

The agricultural portion of the building was by far the best in design, though comparatively rude; but, unhappily, since the exhibition was a very poor one (the provinces being scarcely at all represented) almost twice as much accommodation was provided as was needed.

We fully believed that a better building might have been erected, affording the same area and advantages as this Parisian Palace of Industry, and avoiding most of its defects, for an amount less, probably, by one-fourth than that which was expended upon it.

Although the observation of these and similar defects was not without considerable influence upon the plans ultimately adopted by the commissioners for the exhibition of 1851, it is not to be imagined that the building for that exhibition (or any of the subsequent series based upon it) was free from numerous drawbacks to the complete success it very nearly achieved.

Whatever the defects of the Paxton system of building may have been, it was at least satisfactory to the Royal Commissioners, that they never assumed the form, or led to the grave consequences apprehended by many of the speakers at the institution of Civil Engineers on the occasion of the protracted, and hot discussion which took place in 1851 upon the merits of the scheme. Those, however, upon whom the duty of keeping the building in going order during the exhibition devolved, came to the conclusion that it was faulty chiefly through the following defects, stated briefly,—

1stly. In the difficulty of applying screens, or blinds to lessen the intensity of the summer glare.

2ndly. In too great fragility of the roof covering leading to constant fractures and passage of window water in stormy weather to the detriment of much valuable property.

3rdly. In the great difficulty through the narrowness of the gutters of getting about the glass roof for the purpose of relieving obstructions to the discharge of the rainfall, and for effecting necessary repairs without doing almost as much fresh damage as the repairs were intended to remedy.

4thly. In providing sufficient ventilation without admitting dust, dirt, birds, fog, mist, leaves, and other nuisances carried freely upon the wings of the wind.

5thly. In the great difficulty of keeping the angles of meeting between horizontal watercourses from Paxton roofing, and vertical face-work watertight.

6thly. In holding a safe balance between economy, and the maintenance of sufficient rigidity to resist vibration and displacement through the action of wind upon large surfaces directly opposed, and exposed to its unbroken violence.

Many of these structural defects, from all of which no building of its class can be quite free, were avoided or remedied in the structure next used for an International Exhibition; but nevertheless it must be admitted that few of the buildings of the past have displayed greater want of judgment in some of their arrangements than did the structure adopted for the French International Exhibition of 1855. The success of that exposition, which cost France an enormous sum of money was really only saved by its brilliant display of fine arts, then for the first time introduced to augment the interest of an industrial exhibition, and by the advance manifested in those manufactures in the design of which the French were easy masters, and certainly played the leading part. It succeeded in fact in spite of, not through its buildings, the chief satisfactory features in which were the handsome proportions, permanent character, and internal aspect of the Palais de l'Exposition

in the Champs Elysées. As a juror in that year I can but echo the groans of my colleagues at the all but impossibility of finding where, or when our duties began, or ended. To the foreign executive, and indeed to the French themselves the nature of the buildings, their number, collocation, and unpunctual completion proved, and manifested almost insuperable defects, and in the pages of the British reports on that exhibition, especially Mr. Cole's and that of Mr. Thompson "on the industrial arrangements," the complaints occasionally rose to a howl of reproach to M. Le Play and his colleagues. It was stated for instance, that the British goods were arranged in three very distinct positions, one being in the Palais de l'Industrie in the Champs Elysées, and the other two at the extreme ends of a supplementary building, called the Annexe by the banks of the Seine. By regulation No. 5 of the Imperial Commission, the reception of goods was to commence on the 15th January, and terminate on the 15th of March, the time in a few exceptional cases to be extended to the 15th of April; but in consequence of the backward state of the arrangements in the Palace, and the incompleteness of the roof and flooring of the Annexe, this regulation could not be persisted in; nearly all the French contributions, and many from foreign countries were received at a much later period, and in fact goods were admitted into the exhibition almost up to the period of its closing.

It is a remarkable fact that there was a total absence of all the usual mechanical appliances in Paris for moving large and heavy packages, not a single crane being provided for that purpose, consequently the work of unloading the waggons was of the most laborious description. Moving and lowering heavy weights by hand of necessity involved considerable risk of damage, and great loss of time.

The general arrangements for the reception of goods at Paris were as follows:—Some of the porters ascended the waggon to the top of the packages, and lowered down by hand to other porters beneath them such cases as they could lift, if too heavy for them to move, the packages were slid down a plank, and no precautions were taken to break the force of the concussion on reaching the ground. If very heavy indeed, the packages were unceremoniously thrust from the waggons. Packages of several tons in weight were thus unloaded. The damage done through this cause was very great, the loss to English exhibitors by breakage of glass alone amounting to several hundred pounds.

The French executive preferred to receive the goods at only one door in the Palais, and for a long time only at a single entrance in the Annexe. The doors for the reception

of goods were situated at the western ends of both buildings, whilst the space allotted to England was, with the exception of the machinery portion, mostly at the eastern end, consequently our packages had to be carried, or wheeled on trucks, the whole length of the building through the space allotted to other countries, and over a floor but ill calculated to bear heavy weights, to the great annoyance of our neighbours, and with inconvenience to ourselves.

In the Annexe, the delays arising from this cause were most serious, packages of all shapes and descriptions, and belonging to exhibitors of all nations became piled up together in one confused mass, and hundreds of English cases intended for the east end of the building, being nearly three-quarters of a mile from the place destined to receive them, had subsequently to be recarted from the western end of the building, and weeks elapsed before the packages were sorted.

The goods naturally came from the railway to the Annexe sorted, those of each country by themselves, and as the building was of great length it would have been easy to have deposited the goods of each country on its own site; but, by the plan adopted, the natural separation was superseded, and the confusion followed which has been mentioned.

By regulation No. 27 of the imperial commission, the French authorities undertook to distribute the packages as they arrived at the exhibition, and deposit them near the places allotted to receive them, but the delay was found to be so great that it became necessary to organize a gang of men for the special service of British exhibitors. These men were kept in the pay, and employment of the English Commission until the final closing and clearing out of the exhibition.

From the unavoidable distance between the different buildings, the divided nature of the allotments to each country, and the unsuitableness of some portions of the building to the class of goods to be placed in them, the classification of objects, either geographically or systematically became impossible.

The space allotted to England was situated in not less than nine distinct places, the Beaux Arts, the Palais, Palais Gallery, east end of Annexe, north gallery of Annexe, south gallery of Annexe, west end of Annexe, the Rotunda, and the space outside the building. These different positions could not be visited without passing through the allotments of almost every other country contributing to the exhibition.

Owing to the distance between the several buildings, the scattered nature of the arrangements and other causes, the work of the juries was one of great labour and difficulty.

Notice has already been taken of the circumstances which led to the removal of portions of the buildings appurtenant to the International Exhibition of 1862, which from the great solidity with which they were constructed had no doubt in the plans of the commissioners been intended for permanent retention in the vicinity of the Horticultural Society's Gardens, and it is not necessary therefore to recapitulate the defects which led to their removal.

It may, however, be useful to note one or two features which marred their success as caskets for the display of industrial gems.

The chief of these were the disposition of what were called "trophies" along the main longitudinal axes of the Palace of Industry. Owing to the equally balanced side lights running along the clerestory of the nave, the shadows from these, which were many of them lofty, bulky, and opaque erections, produced a disagreeable effect, and the lights falling upon the sculpture were actually disfiguring in many cases, as will be remembered no doubt by some who may have observed the failure of Captain Fuller's really clever and well modelled group of Queen Godiva, upon its admission to what at first, and before trial had been looked upon as the post of honour. Another defect certainly existed in the gloom which reigned perpetually under the galleries, and under the great extent of flooring of the first floor halls which accommodated the pictures. From any analogous defects, however, the great glazed courts and the annexe were quite free, and in those the exhibition was little else than a complete success.

The great defect of the 1867 Paris Exhibition was the want of elasticity caused by the attempt to follow out too strictly a preconceived scheme of combining geographical, and scientific classification through concentric and radial allotments of area, as originally and very ingeniously conceived theoretically by Mr. George Maw of Brosely, and by him submitted to the French Commission, and its chief acting representative M. Le Play, prior to the date of determining upon the plan of the building finally executed. As each country was to have a regular strip of the quasi-elliptic building, it became evident as soon as the building was started, and allotments of space made, that two inconveniences would arise from this arrangement. In the first place, if any country sent more exhibits than could be shown

in that space of the main building allotted to it, either some exhibitors would be favoured with stalls in the main building, whilst others had to be relegated to some possibly distant outbuilding, or there was the alternative of showing a portion of each exhibitor's display in the main building, and leaving the remainder of the same firm's produce to be probably unnoticed in an annexe, or separate erection, near to, or far from, the rest of that exhibitor's goods, as chance or favour might direct. The second obvious inconvenience was that occasioned by the omission of certain countries to send different groups of exhibits, demanded of the various contributing nations, so leaving most awkward gaps. This must have been so evident from the earliest moment, that it is a matter of some slight astonishment that practical men, such as were many of the commissioners of the 1867 exhibition, could have pledged themselves to such an extremely theoretical scheme as the plan of this exhibition, with the belief that it could be at all strictly adhered to. Could they have thought it likely that an art producing country such as Italy, or a half civilized land such as Russia, would contribute machinery in any adequate proportion to that claimed for England? Or was it a whit more natural to expect a flat country like Holland to exhibit mining produce in at all the same proportion as its Belgian neighbour?

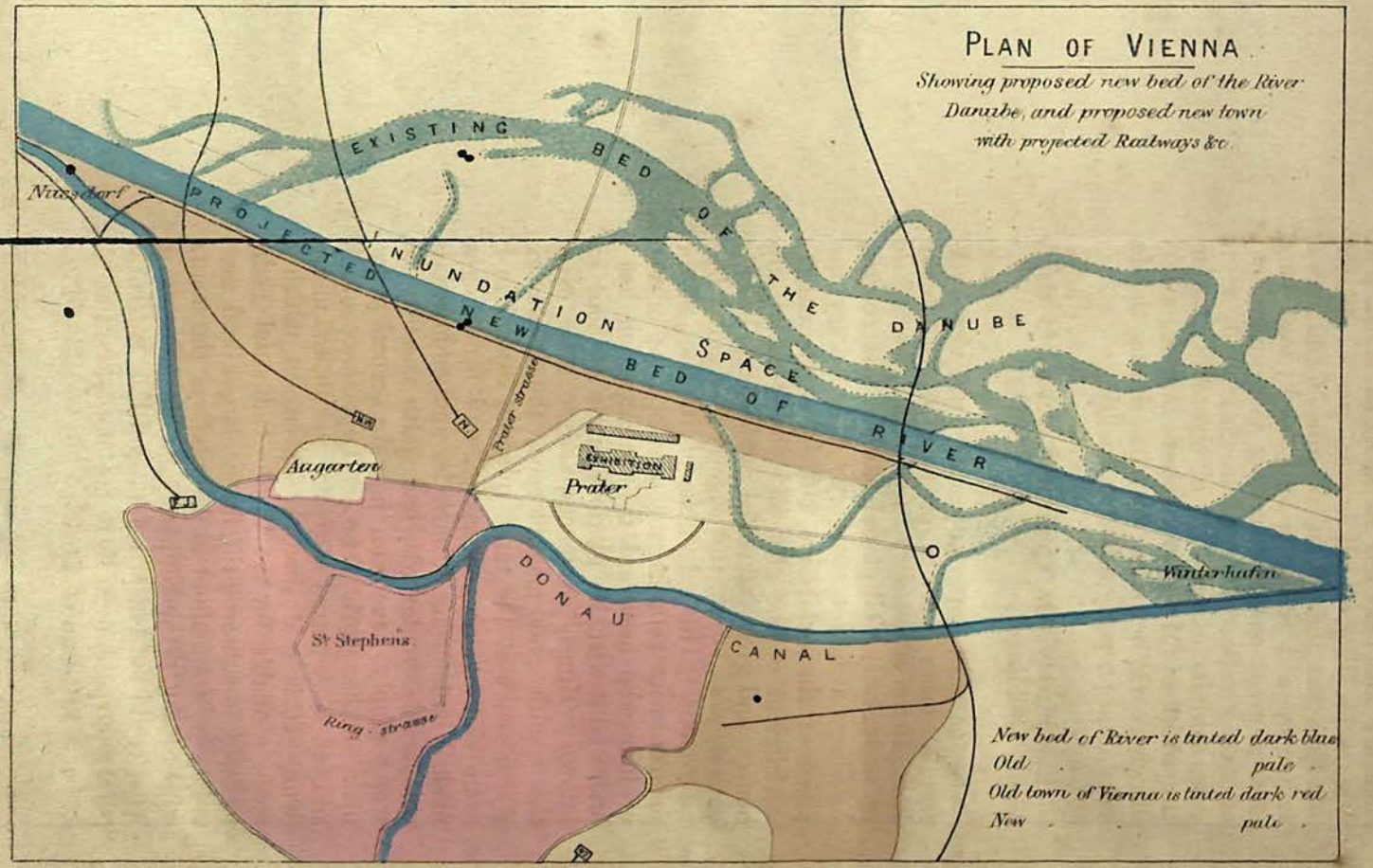
Another defect of this exhibition was the formation of the semi-circular ends of the building. These caused much extra outlay, especially in the provision of shafting for the machinery in motion, over what would have had to be spent if the ends of the building had been kept square, or even semi-octagonal, on plan; and the discomfort of finding oneself constantly walking slightly either to the right or left, instead of going on in a straight line, was more felt than would be imagined by anyone who had not experienced this unpleasant sensation, which destroyed a due sense of rectangularity of planes and lines, besides involving great complexity in structure.

A third defect, which, however, was not so great here as it was in the exposition building at Vienna, was the method of lighting. The light was, unlike the glazed and partially glazed roofs of some of the earlier exhibitions, admitted through vertical windows at some height from the ground. The effect of this was, that any large or lofty screens placed between the side lights cast shadows on the opposite wall, as the light from the high window, on the same side as the shadow, was too far above the darkened object to counteract the mischief caused by its opposite

window. The Paris Exhibition building was however so lofty, and the windows were so large, that this inconvenience was only felt to a slight extent; whereas in the Vienna building, which was comparatively low, with smaller windows, the light from one side of the nave or side courts, falling upon a screen or lofty trophy near the opposite wall, caused great opaque shadows comparatively out of range of strong reflected light, throwing many of the more delicate exhibits almost out of sight. Thus, for instance, all the effect of Mr. Owen Jones's minute, and very beautiful drawings was never at any time during the duration of the exhibition properly and duly visible.

E.—Fifthly. On structural success in the Vienna Exhibition Buildings.

In one most important respect the city of Vienna differed from all other cities in, or adjacent to which, International Exhibitions of industry have been hitherto held,—possessing an undeniably well placed site for the congregation of vast buildings available not only for temporary use for the purposes of the exhibition, but for permanent retention to the enrichment of the city and the state, as supplying warehouses, and great industrial establishments previously almost entirely wanting in, and eagerly demanded by, the Austrian metropolis. The exigencies of its lines of fortification had for centuries retarded the development of the city for civil or industrial uses, and their obliteration has of late years endowed it with its glorious circle of boulevards,—its well known "Rings," evidences, and to some extent sources, of the wealth and magnificence, the lavish expenditure of which make it the most splendid capital in Europe. The same skill, energy, enterprise, and forethought which have made Vienna what it now is, and endowed it with its incomparable boulevards, and quite recently with its noble water supply, have been now for several years concentrated upon another work of no less importance and likely to prove an even more potent source of wealth, and metropolitan grandeur. It is said that the extent to which the buildings made available for the Vienna Industrial Exhibition might be made to subserve the future larger and more permanent enterprise I am about to describe was the main consideration which induced the Emperor and his ministers to consent to what could not but prove a profitless enterprise for a temporary purpose, even if it did not ensure an almost certain loss of a vast sum of money.


PLAN OF VIENNA
Showing proposed new bed of the River Danube, and proposed new town with projected Railways &c.
EXISTING BED OF THE DANUBE
PROJECTED INUNDATION SPACE
NEW BED OF RIVER
Nussdorf
Augarten
Prater strasse
EXHIBITION
Prater
Winterhafen
DONAU CANAL
St Stephens
Ring strasse
New bed of River is tinted dark blue
Old pale
Old town of Vienna is tinted dark red
New pale
Vincent Brooks Day & Son Lith

I. To the Austrians then must be awarded the merit, for the first time in the history of international industrial exhibitions, of looking ahead with sufficient discretion to make outlay upon the scheme of the exhibition permanently applicable to the supply of national industrial wants, and to the creation of permanent sources of wealth in the future.

In what way this was proposed to be effected can be best apprehended by an examination of the diagram now submitted. (*See facing page.*)

To the north of the city of Vienna lies the river on which it stands, the Donau or Danube, which there consists of a main body of water and numerous arms all deviating vaguely from a straight line, and differing in level so widely and with such eccentricity as at one time to be too shallow to take an ordinary ship, and at another, within a very short interval, to be so full as to flood the whole country for miles around; the safety of the city in fact resulting from its lying at some distance from this troublesome river. For these and other reasons, what is known as the Donau Canal, a natural arm of the Danube, improved by art to a uniform width of about 150 feet, is now alone used for ordinary navigation. This enters the Danube at one extremity, about 5½ miles due east from St. Stephen's, the grand church that stands in the centre of Vienna, and at the other end at Nussdorf, nearly 4 miles north-west from the same cathedral. The Donau Canal passes through the city itself dividing the Leopoldstadt from the rest of the metropolis, and the northern portion of the Ringstrasse forming the south or Francis Joseph Quay of the canal.

To understand quite clearly the new project in connexion with the Danube, notice must be taken of three great railway stations. The Francis Joseph, marked F.J. on the plan annexed; the North-Western Station, marked N.W.; and the Great Northern Station, marked N.

The inconvenience of the river having been felt for centuries, especially at those periods when it overflowed its banks, as in 1830, a commission was appointed as far back as the year 1850 at the instigation of Herr Bruck, Minister of Commerce, and the majority of the members came to the conclusion that the bed of the Danube should be shifted from its existing position to its proposed new site, that the new river should have a general width of 1,245 feet, and that it should extend from where the Donau Canal enters the Danube to where it leaves the river at Nussdorf. It was also determined to build embankments, and continue the

Prater Strasse over the river. But, as is so common with our own Royal, and Parliamentary commissions in this country, the effect was absolutely nil, and in 1864 a new commission was appointed, composed of representatives of the state, the landed proprietors, and the city.

This commission set to work with a will, and having consulted many eminent native, and foreign engineers, with a view to ascertain what improvements might be made concurrently with altering the course of the river, confirmed most of the advice of the commissioners of 1850, and further decided on building a new town north of the Donau Canal, between the Leopoldstadt, and the new river. To make this the more effective, they determined to bring in communication all the railway systems running through Vienna, and to make one great central station for the whole of them.

After this commission had finished its labours, another was appointed on the 17th March 1869, and the works commenced thereupon are still progressing.

The bed of the new course of the river is divided into two widths, the bed proper 934 feet broad, which has a depth below high water mark of over 22 feet, and the north bed which is only covered at high water, and which, running parallel to the centre bed with a mean width of 1,557 feet, is confined on the north by an embankment wall. To the south of the main bed the ground shelves upwards forming a great quay; that portion next the Prater being intended for large bonded warehouses.

We can now see the ultimate purpose to which the industrial hall of the exhibition is to be applied. This immense building is destined to form a granary, and storehouse of immense value in times of peace, and of incalculable good in time of siege, should such an untoward event occur, as the depôt in which food, and other necessaries could be stored for the whole city for several months. A new line of rails is further in course of construction, running parallel to the river, crossing the rails from the three stations above-mentioned, and also the rails of a new line going north and south, which will run to the projected eastern suburb of Vienna.

The exhibition contained many exhaustive plans, and detailed designs applicable to the above, and other projected works in connection with this project testifying satisfactorily to the ability, and prudence of the scheme; and the advanced state of the main works, of which an admirable view could be obtained from the gallery at the top of the rotunda roof,

bore witness to the progress already made in the realisation of the project.

II. If the display of forethought, in relation to the ultimate conversion to profit of outlay which, but for that quality, could have only resulted in aggravation of a certain probable measure of loss, formed the first, and most prominent item of success in the arrangement of the Vienna buildings, its second similar leading item may be looked for in the generally agreeable, and prudent architecture of the whole. All Herr Hasenauer's work appeared to every one most creditable, agreeable to the eye, symmetrical, well proportioned, pleasantly drawn, and neither too bald nor over ornate. Where enrichment seemed requisite no part was left nude or shabby; and where extreme simplicity or rigid economy precluded ornament, such simple styles of building and construction were resorted to as best dispensed with what could not be prudently afforded. Taking, for instance, the Emperor's pavilion as the extreme of splendour, and the gallery for the illustration of agriculture as the extreme of simplicity, both were equally treated with appropriate expansion and reticence. "Keeping" was well sustained, and quiet effect with immense extent was as well written upon the stupendous gallery for machinery, as magnificence in repose distinguished the general character of the apartments in which Austria welcomed the assembly of the illustrious jurors she had invited from every quarter of the globe to assist her in estimating the skill and powers of the artists, manufacturers, and artizans, whose genius, enterprise, or industry had furnished the feast of intellect she had been aiming at offering the whole world.

III. Upon the whole, the geographical, or rather topographical, arrangement of products which was adopted at Vienna may be regarded as the most convenient one which could have been determined upon; especially where the site, upon which the buildings have to be placed, offers length enough from east to west to allow of the placing of spaces allotted to countries in their proper order of orientation; and where it possesses width enough, to allow classes of products requiring separation, in different kinds of structures, such obviously as machinery in motion, and at rest, and agricultural implements, to be placed in lines parallel to the main structure from east to west, so as to allow of a collocation of those exceptional classes of products, corresponding as nearly as possible with the order in which the products of miscellaneous industry may have been arranged in the main structure. A very elementary knowlege of geography

is in that case sufficient to furnish a clue to the visitor without the necessity of constantly referring to a map, and enable him to find his way to the products of any country he may desire to examine, without incurring any great risk of missing the object of his pursuit. In exhibitions of moderate extent the consequence of the visitor's missing his way and having to trace, and retrace his steps is of no very serious moment, but when, as at Vienna, walking up and down the palace from east to west and back again twice instead of once meant walking 12,000 instead of 6,000 feet, the result of any such miscarriage became of increasingly serious importance as hour succeeded hour, and the student approached the ultimate limits of his powers of strength and endurance.

I think also that the Viennese system of considering that the longitude of the parent country should govern the position in orientation assigned to any colony belonging to that country was the simplest, and best. For instance, I consider that it was better to group Java with Holland, or India with England (as was done), than it would have been to have remitted Java to the east of India, or India to the east of Turkey.

IV. A fourth success at Vienna was unquestionably derived from the unprecedented variety, and importance of the supplementary buildings grouped about the main palace of industry, and illustrative on a scale of great splendour and completeness of national habits, manners (or want of manners), customs and methods of construction. The idea which was worked out for the first time on an international scale, as we have already seen at the Exposition at Paris of the year 1857, was carried out at Vienna on a much grander scale, and with especial magnificence through the rivalry of certain of the eastern potentates. The most satisfactory reproduction architecturally was unquestionably the palace of the Viceroy of Egypt. The design and drawings for this most satisfactory specimen of Cairene building were prepared by Herr Schmaranz, an Austrian architect long resident in the east, and the whole was carried out with the greatest skill, and fidelity by Egyptian workmen specially sent to Vienna by the Khedive. This palace combined all the usual features of an ordinary dwelling-house with a sumptuous mosque, and divan complete, in the richest decoration, and with many features of originality both in the design, and technique, and a regular farm and stable department fitted with dromedaries, and all other animals usually accommodated in Egyptian farm establishments, upon a large scale, with primitive but interesting illustrations of usual arrangements

for water raising and irrigation. The whole in fact was of singular perfection and completeness.

Of at least equal fidelity, although on a comparatively small scale was, apparently, the Russian farmhouse, entirely constructed of wood with complete fittings and decorations, many of which were novel, and pleasing in the highest degree.

The Turkish fountain, a full sized reproduction of a well-known model at Constantinople, was erected in temporary materials, for the most part casts of the elaborate ornamentation of the original, and formed a very picturesque, and pleasing object in the open space between the eastern extremity of the palace of industry, and the great galleries for the fine arts.

Space fails us wherein to separately dwell upon the chief successes of these illustrations of out of the way life, but the subject should scarcely be quitted without a few words of commendation for the representation of national habitations in Persia, Morocco, Japan, Sweden, and many of the wilder provinces of the Austrian empire.

V. As for its fourth success the Imperial Commission was for the most part indebted to the lavish expenditure of foreign sovereigns, and foreign, and native princes, and potentates, so for this its *fifth* it may be regarded as indebted to the spirit of enterprise of many great commercial companies and establishments, who erected buildings of especial interest as prominently exhibiting products of industry of exceptional character, and many of them of commercial value, magnitude, and interest. Foremost among these were the buildings in which the whole of the daily preparation of the "Neue freie Presse," the leading newspaper of Vienna, was carried on, from the collection of literary material to the issue of the printed sheet; that in which the products of the great Austrian Iron Company were exhibited; that in which the enormous traffic of the Austrian Lloyds' Company was illustrated, and many others of nearly equal importance, including the products of the famous company of Krupp and Co. at Essen in Prussia.

VI. A sixth marked success at Vienna may be attributed to the unsparing use of novel modes of building, some of which architects are often too apt to regard rather as monopolies of civil engineering than as invaluable resources for use in their own profession. Such features when used (as at Vienna unsparingly), in union with structural forms recognized by the eye of taste as associated with standard models of elegance in styles of architecture from which no ancient precedents can be derived for the determination of

the forms, and proportions which such novel modes of building can well be made to assume, accommodate themselves admirably to the complicated, and often unexpected necessities of structure incident to new orders of wants born of the nineteenth century.

By way of practical illustration of this proposition reference may be made to the frank adoption of light wrought iron lattice girders, and simple zinc roofing in combination with Renaissance mouldings, capitals, and arabesques of fairly pure character. The result was unquestionably more satisfactory than it would have been if, by casing, or applying needless ornamentation, any attempt had been made to mask or conceal the functional necessities of the iron girders, or the sheets, and rolls, or laps of the ordinary zinc roof covering.

In their successful union of ornamental architecture with simple, daring, and novel construction, in iron, and other materials the architects, and engineers of the Vienna Exhibition only availed themselves with steadfastness of the source of success which has contributed so much to make the vast, and splendid new buildings of that city the most practically economic, and satisfactory specimens of modern civic architecture which have yet supplied, efficiently, the complex wants of the nineteenth century, and at the same time preserved the aspect of forms of grace, derived from the traditions of classic, mediæval, and renaissance art. As yet, perhaps, in Vienna scarcely enough has been derived from the experience of the middle ages in which Germany is nationally so strong, but from the art patronised by the merchant princes of Venice. Florence, and Genoa, a large measure of the architectural splendour of the new city has been appropriated.

VII. A seventh source of success was the convenient placing of the offices, and bureaux to which the public and the exhibitors required frequent and easy access. At each principal entrance was a well placed ticket office; and as no change was given, money changers had handy stalls close by, where for a slight charge, the foreign money of any strange country, and the large notes of Austria itself, were changed for whatever coins the visitor to the exhibition might desire. Close by the chief entrance in the Prater Allée were, to the left, the Commissionshaus or exhibition clerk's offices, where all inquiries were answered, and all illustrious visitors quickly notified to the Central Management, owing to the look out easily obtained from this department, capitally situated for the purpose it was intended to serve. To the right, were the postal, telegraph, and customs offices, with all conveniences for letter writing, and sending telegrams, and where could be

ascertained and paid the imposts, and other duties in connection with the articles exhibited in the buildings adjoining. These two buildings were also of great service on account of being so close to the Imperial and Jury pavilions. Another little office, which also added much to the general comfort of the visitor, was the office for obtaining tickets of admission to all the principal theatres, a great advantage for the stranger staying in Vienna only for a limited time; as the exhibition grounds were at a considerable distance from the heart of the town, and the visitor was thus not bound to leave the exhibition till the necessary time approached for him to start for the theatre, at which he had ascertained in the course of the day he could obtain a seat, often a very difficult matter, especially in the case of the opera, as any one who was in Vienna at that time will well remember. A further comfort to the visitors to the exhibition was ensured by the immense lengths of covered passages which stretched from the front entrance to the Industrial Hall, and from the Industrial Hall in every direction to the machinery department, fine arts gallery, and back entrance. These passages enabled every one to walk in the dry if the weather was wet, and to walk in the shade if there was a broiling sun. In the exhibition building itself additional bureaux were of great use, more especially from their central, and commanding situation opposite the main entrance to the grounds, and connected with the rotunda. Here were stationed the clerks in connexion with the service of the building, the firemen, the police, and the various officials, on whom depended in a great measure the good or bad success of each day's work at the exhibition. Due provision was here made for medical assistance at all times in the event of accident, or sudden indisposition.

VIII. The eighth cause of success at Vienna was the plentiful supply if not cheapness of cabs, and other conveyances, the good standing places reserved for them, and the absence of vehicles loitering round the main entrance, and so blocking up the passage way for carriages setting down and foot passengers going, and coming. Opposite the western entrance to the exhibition was a cab-rank with standing for a vast number of vehicles, and this station was kept in constant telegraphic communication with the principal entrance in the Haupt Allée of the Prater. By this, two advantages were gained, firstly, nothing was allowed to linger about the front entrance, so that when a coach was telegraphed for it was brought up to the main covered waiting places at once, and visitors were thus able to leave speedily without having to push through crowds of carriages, and their coachmen

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waiting for their fares; and, secondly, there was no opportunity afforded to the cabman of refusing to take up his hirer in order to run his chance of a better fare, the whole being kept under the strictest surveillance by the police, constantly on duty at the chief entrance.

IX. A ninth great success at Vienna, resulted from the facilities afforded by the tramways, and the carriages running all round the city upon them, for bringing any of the inhabitants, or visitors staying in all the principal hotels to the station in immediate proximity to the western entrance to the exhibition. This was effected steadily from morning till night for a very reasonable fare and with very tolerable rapidity, under due protection from wind, weather, or rapacious coachmen and "roughs."

X. What, after all, however, cast brightness over many occasional faults, and drawbacks whether affecting the building, or any of the arrangements connected therewith, turning many a failure into a success, was the hearty spirit of hospitality shown by the Austrians to their visitors, from the Emperor, and Baron Schwarz von Senborn, and his staff down to the attendants who seemed uniformly civil and obliging. The general motto even in the face of dreadful loss, and overwhelming confusion at times seems to have been "à mauvaise fortune toujours bon gré."

F.—Sixthly, On drawbacks to success in the Vienna Exhibition buildings.

Our previous description of the structures, or rather town, which constituted the Vienna Exhibition, must have been altogether inadequate if it has failed to impress upon the reader a clear idea of the almost superhuman task which the Baron Schwarz von Senborn and his colleagues had imposed upon themselves. Human ingenuity, despite Titanic energy, courage, strength, and skill was at times in many respects overmatched. The wonder is not that drawbacks to success should have existed, but that success should have been achieved at all, when the difficulties of every description, scale, cost, time, complexity, variety of interest, casualty, misadventure—natural fruit of human agency—are thought of, and fairly apprehended.

One of the most regrettable effects of drawbacks in the plan, or mode of building of any structure is invariably the terrible increase of difficulty engendered by such faults of plan, or defective building when the practical labour has to be encountered of carrying out the purpose for which any

structure may have been intended. To succeed in the face of such defects may command an enhanced respect for those who conquer in despite of all; but as we observe mistakes of principle, or misapprehensions of means to ends, we often have to only the more deeply regret to recognise how frequently easily avoidable at an early stage the errors may have been which most cruelly enhanced the difficulties of, and imperilled the results aimed at.

Such errors often give the "coup de grace" to the efforts of those already beset by all but insuperable difficulties, and almost unavoidable risks of failure. It is one of the most dangerous accompaniments of any thing like misapprehension of principle in point of structure that it is often not until those who have sown are far advanced in reaping that they discover the all but fatal, or at any rate disastrous, consequences of faulty seed.

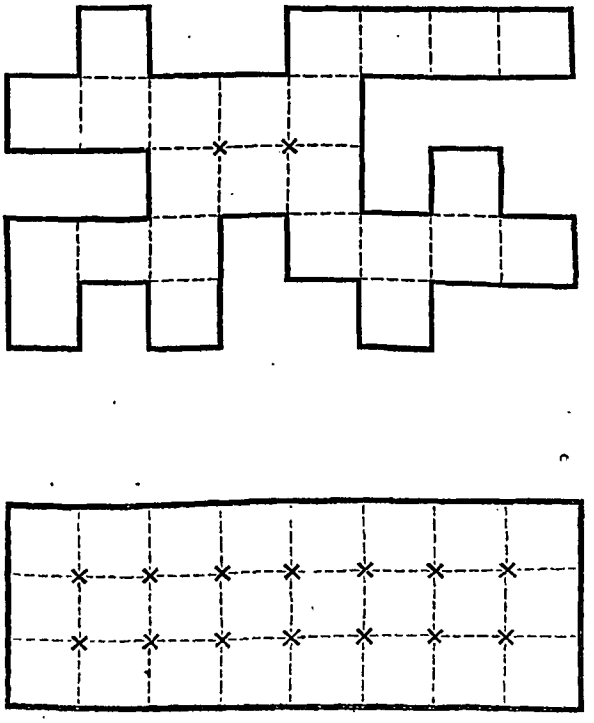
I. Now from its very inception the Vienna scheme carried with it, like the tower of Babel, the insuperable error of being cast upon too vast a scale. It was huge and splendid, but in every way cumbrous. Parisian, and indeed English experience had already sufficiently strongly marked the limits beyond which popular interest in variety, and complexity even of the most beautiful objects cannot be sustained. The intellectual banquet palls upon senses dulled by fatigue, and if enjoyment fails, the most nourishing mental food ceases to assimilate. The human eye can really take in, with what the great Italian architects were wont to study with much care, the "colpo d'occhio," but a limited dimension; and beyond such dimensions no increase of enjoyment can be derived from additional scale, or extent of structure. At Vienna those limits were transcended, and although by change of position repetitions of similar effects might be observed, a more powerful effect could seldom be admired at any one moment than another. Effects aimed at by the architect were incessantly marred by the audacity, if the term may be used, permitted to the exhibitors who were suffered to usurp, and monopolise the best points of view, and too often to block up vision in directions where architectural exigencies seemed most urgently to demand "ample scope and verge enough" within which the eye might travel at will without check, or hindrance.

II. The drawbacks to the success of the splendidly daring central feature of the Vienna palace of industry were, in the judgment of many, serious and irremediable, obscuring great, and unquestionable merits, as already sketched in the preceding section of this report. It was considered by some good judges larger than was quite suitable for its purpose

or for agreeable effect. Its vastness overpowered the scale of every architectural feature brought into comparison or contrast with it, and it effectually swamped every effort the exhibitors could make to induce their exceptionally splendid products to hold their own against its overpowering mass, and area. What they might have done if the illumination of their goods had been altogether satisfactory cannot now be told, since the depressing effect of the comparative paucity of light due to the solid cone, damped all brilliancy of effect where such a result should have certainly culminated. In this particular, as well as in a more fitting apportionment of scale, and style between the lower zone of the cone and the drum with its openings upon which the cone was planted, the design of the building committee of the exhibition of 1851 was apparently superior to it. Within a moderate distance inwards from the periphery of the rotunda the light was almost too brilliant, partly owing to the open arches which admitted light from the nave and transepts, and partly from the rays descending from the windows of the top story of the roof which only fell on the level of the floor near to the external line of the rotunda, but all of the floor within a radius of about 150 feet from the centre received little else than reflected light, and seemed, by contrast, always in comparative gloom, enhanced by the aggregation of lofty structures placed upon it by exhibitors, each one interfering with its neighbour.

III. The element which appeared most of all wanting in the general scheme of the Vienna Exhibition buildings and especially the Palace of Industry, was ready *elasticity*. Its plan was far too rigidly defined, and its turgid, and scarcely controllable waters overflowed their banks with every change of tide. The very subdivision of the whole enormous area inclosed, and covered into a great number of apartments bounded by lofty walls, while adding vastly to the cost of structure, lessened general effect, enhanced the difficulties of watching, and tended by too great redundancy of products in one section, and too great sparseness in others, to create, and perpetuate discontent at unsatisfactory exhibition in very many instances. In most of these the measure of elasticity which would have resulted from supporting the roof only by rigid, and permanent materials only at nearly uniform points of regular geometrical recurrence over the whole area, leaving definitions of limits of areas assigned to be marked only by comparatively moveable and manageable enclosures, would have obviated much in the general arrangement of industrial products which was greatly to be regretted.

To what extent this system of what may be called building "on *the pavilion system*," instead of encircling a great area only by walls of inclosure, leaving roofing only to be supported at points of intersection of lines of columns, increased expense can scarcely be apprehended without the test of practical experience, or experiment. Reference to the diagram here inserted may probably make this observation clear, which without such aid might be all but unintelligible.



Both these plans show the same amount of enclosed space. In the one case, 24 squares are enclosed by 22 lengths of wall (calling each side of a square 1 length), and 14 columns, and in the other case by 46 lengths of wall and 2 columns. Now, supposing each length of wall to cost 50*l.* and each column 20*l.* in the first case where the space enclosed is a regular parallelogram, we get the outlay in pounds $22 \times 50 + 14 \times 20$ or 1,380*l.*; in the case where the walls run in and out, we get the outlay in pounds $46 \times 50 + 2 \times 20 = 2{,}340l.$, very nearly twice the cost of the first named method.

In the main hall of the Vienna Exhibition, to enclose a superficial area of 704,400 feet, walls were built 22,620 feet long, whilst the rotunda under the dome having a periphery of 1,319½ feet encloses an area of 138,544½ superficial feet;

the proportion of lineal feet run of wall to superficial feet, enclosed thereby being in the case of the dome only 1 in 105 whereas in the main hall, the proportion was 1 in 31. The ratio therefore was more than 3 to 1 in favour of the dome plan over the straggling system of walling employed in the great Industrial Hall.

IV. Another defect at the Vienna Exposition which caused, perhaps, more personal inconvenience to many than all the other defects together, was the mock modesty displayed in the attempt to hide from view the waterclosets, and other necessaries, instead of placing them where most handy, and easy to find. They were too few in number, and if the exhibition had turned out the success it was hoped to have been in abundance of visitors, this scarcity would have been most awkwardly felt. Beyond their being so few in number and hidden away, there was the mistake of not placing them at symmetrical points on plan. If a visitor, for instance, had at Vienna occasion to avail himself of a convenience at the eastern end of the building, he could by no means feel confident of finding a corresponding place at the western end. The charge for washing, and using retiring rooms was also much too high, especially considering that even for the poorest visitor, or attendant, there was scarcely any possibility of avoiding it, excepting at a great sacrifice of time, and at the cost of a very long, and often harassing walk.

V. A further cause of some annoyance, and anxiety was the closing the building at night by means of iron shutters, which were used both as external guards, and as screens to cut the main building up into sections. It was certainly vexatious for a tired visitor, who happened after the close for the day of the Industrial Hall, to find himself at the western end of the machinery annexe, or in the western agricultural gallery, to be obliged to walk nearly all round the building, over a mile, to get out at the front, or southern entrance, or the two western, the only ones left open to the public to leave by. This was a still greater source of anxiety to the police, and watchmen, who were then debarred from proceeding directly to any particular spot in case of accident inside the closed building. Thus if a pipe burst, or any little matter began to get out of order, there was no means of getting immediately at it; but long detours had to be made, allowing possibly trifling mischief at first to become serious in places where, if reasonably direct access had been possible, a few minutes might have sufficed to stop the progress of the evil, and to repair any damage it might have caused or done.

In conclusion upon a review of the experience of the past, including in that term the Vienna Exhibition of 1873, it may be doubted whether we may yet have attained the best form of exhibition building, or whether it may not yet have to be sought in modifications of several of the already attempted schemes. The proper type, with certain necessary adaptations to its particular purpose, seems perhaps to best present itself in some of the largest railway stations, covering vast and well lit areas, such for example as the great station at Munich, or some of the fine new stations at Vienna, Genoa, and Turin, or indeed in our own clever specimens of construction at Victoria, and King's Cross, or our magnificent ones at St. Pancras, Liverpool, and Birmingham. An improvement on the plans, while following out the chief ideas of the late M. Hector Horeau, or of Mr. Turner of Dublin, or more especially that of Mr. Owen Jones as proposed for the Manchester Fine Art Exhibition of 1857, might also lead towards the desired end. The partial defects of the Paxton system, and of the brick built permanent pavilion system, have been already pointed out, and in their places it may be well possibly to seek for a type of building with no internal walls, but with a roof supported on light cheap columns, with the light coming vertically down from near the apex of the roof in our climate, or from vertical windows easily shaded by blinds, or venetians in hotter countries.

The great inconvenience caused by the breakage in, and the leakage through, the joints of entirely glass roofs might be remedied by having a series of roofs at an angle of about 45 degrees glazed in their upper half only. This would further allow at the junction of the glazed, and opaque portions of the roof, as in many railway stations, of the insertion of upright framed work, to carry louvres or other means of ventilation, readily accessible, possibly, from narrow external galleries. It may be hoped that with their usual ingenuity, and skill, our American contemporaries may solve the problem, and that in the stupendous efforts they announce as in process of concoction, a greater measure of common sense united with just appreciation of architectural beauty may prevail than has hitherto been brought to bear upon the development of any perfectly satisfactory buildings for the purposes of International Exhibitions.

PROFESSOR ARCHER.

POTTERY AND PORCELAIN.

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Report on Pottery and Porcelain.—By Professor Archer, F.R.S.E., Director of Edinburgh Museum of Science and Art, President of Royal Scottish Society of Arts.

As there is no branch of art which has received greater impetus from international exhibitions than that of Ceramics, it was only fair to suppose that the Weltausstellung of 1873 would present a remarkable display to those who can remember the dawnings of the revival in the London Universal Exhibition of 1851. Nor have such expectations been disappointed; at no era in the world's history has such a show of man's power to mould the plastic clay into forms of beauty ever been seen. Moreover, although the higher branches of the art have only as yet been developed in a few well known centres, it is abundantly apparent in the present exhibition that a feeling for its æsthetical principles has permeated human society to such an extent that even the humblest potters in the most distant countries show that they are alive to the necessity of supplementing utility with good taste. To those who, like the reporter, have studied the history and effects of great international exhibitions from their dawn in 1851 until the present time it is in the highest degree interesting and instructive to observe what powerful and manifold interests they have excited in the civilized world, but in no branch of human industry is this so apparent as in the manufacture of Ceramic and vitreous wares. In our own country especially, the pottery of the people, which is the truest indication of the good or bad taste of a nation, was debased in the extreme, and although it is now far from what we should wish it to be, it is, nevertheless, equal to that of most European countries, whilst in the higher walks of the art we stand on a par with the best in the world, and, in some respects, even higher. Moreover, we have attained this position without State aid, simply by private enterprise stimulated by public patronage growing out of the taste created and fostered to a large extent by the recurring exhibitions, which act as universal instructors.

The value of the potter's art to a nation can hardly be over estimated, for in supplying some of the commonest wants of the household the eyes of those using them can unconsciously be instructed in the beauties of form and colour, and even in pictorial art. And so certainly is this

accomplished that we venture to assert without fear of contradiction that even amongst the poorest, the pottery pedlar of to-day would not be able to dispose of the Staffordshire wares, which many of us remember in our childhood as the common furnishing of the cottage dresser and cupboard, and no well educated political economist of the present day will deny that a nation's wealth is increased by the diffusion of good taste amongst the people. It may be thought by some from too cursorily glancing at our ordinary crockery shops that there is no great improvement, and that very bad taste is abundantly shown, and this is true in the abstract, but all Europe, and perhaps even the more ancient civilizations of India, China, and Japan, are in a transition state in matters of art. A new Renaissance has commenced, and in spite of adverse critics, it will go on. It may be that the result will not equal its predecessor, but if the history of the older Renaissance be fairly studied it will be seen that its commencement was certainly not more promising, and I venture to say not so much so as the present. One thing is quite certain, the artistic results of the Renaissance period, however much they influenced the tastes of the wealthy, had but little influence on the masses, whereas the movement now going on permeates every class of society. It is true it does not at once annihilate the errors of the past. It does not all at once substitute good taste for bad, but like all really good reforms it gently replaces the bad by the good, without doing violence to old prejudices. International exhibitions and their far-seeing originators have done vast good in turning the downward flow of national taste in this, and other countries, and in every branch of art industry their good results are evident, but in none more than in pottery, and porcelain, for it is peculiarly well adapted to foster art tastes. A mass of clay may be formed into a vessel entirely devoid of beauty of form, but yet quite sufficient for the purpose of holding a fluid, or other matter; hence, when it has added to it another qualification, that of pleasing the eye by its beauty of form, colour, or decoration, it becomes an art educator, and when this quiet and unobtrusive instructor mixes up with our every-day life, it is sure in the end to succeed, and if well directed will diffuse true artistic taste in every home to which it finds access. Hence it is that the love of pottery and porcelain has a strong hold upon those who have studied it and learned its power as a cultivator of taste for Art, and although they are often thoughtlessly ridiculed for it, they are nevertheless right, and in due time the correctness of their taste will be admitted.

It will be convenient to place the subjects of this Report under four great divisions, viz.:—

1st. Pottery in its most simple condition, that is as baked clay.

2nd. Pottery glazed, and glazed and coloured.

3rd. Porcelain.

4th. Stoneware.

And it is proposed to say only a very few words on the nature of the differences which exist between these four divisions, as they have been so often previously described in reports and works specially devoted to the subject. The object of this Report being only to point out their development in the International Exhibition in Vienna.

First, then, pottery in its simplest state comprises objects which have been formed out of plastic clay, either pure as dug from the earth, or mixed with other ingredients to give it consistency or colour. Consequently it comprises bricks, tiles, terra-cotta, and domestic utensils of the most primitive kind. It is not proposed, except in the most general way, to treat of bricks and tiles, but terra-cotta and earthenware vessels formed a very important feature in the exhibition. The principal exhibitors of brick and tile work, except the bricks used for furnaces, were, of course, chiefly local. One of them received the well-merited reward of a diploma of honour. The firm to which this award was made is the Wienerberger Ziegelsfabriks und Baugesellschaft. Whether we regard the extent, or the importance of the exhibits of the Vienna Brick and Building-material Company, the propriety of the award is manifest in the general quality of their manufactures. They were only surpassed by one firm, which was for reasons to be mentioned hereafter *hors concours*, but in the great range of their manufactures, and the extent to which they displayed them in the exhibition, they had no rival. A magnificent triumphal arch at the south-eastern end of the exhibition buildings embodied examples of most of their various manufactures, viz., uncoloured, and coloured bricks and tiles, mouldings, and panelings, in great variety, terra-cotta bas-relievos, and statuary and maiolica decorations, and although erected as a show-card, so to speak, was nevertheless in good taste in all its details. Besides this structure were separate specimens of nearly all their manufactures, and also an excellent model of the immense brick-kiln, on Hoffmann's system, at their works, which produced in the year 1872, 45,000,000 of bricks. The works employed 15,000 workmen, and a capital of 1,500,000*l*. It is without doubt the largest establishment of its kind in the world, and

is conducted with the greatest spirit. Employing besides its vast host of labourers, skilled artisans, and artists of the highest excellence. Without the spirited enterprise of such a company the marvellous extension and improvement in the city of Vienna since the destruction of its fortifications in 1858 would have been impossible, but not only has this gigantic undertaking been able to supply the greater part of the requirements of the capital city, but it has also furnished provincial towns with vast quantities of material. Since its establishment in 1844 it has turned out 170,000,000 of bricks. In granting the diploma of honour it was the duty of the jury to take into consideration a variety of subjects, besides the mere quality of the articles exhibited, viz., the capability of the producer to supply a similar quality equal to the demand, at a rate which would admit of general use, the magnitude, and good management of the producing works, and their general importance to the public, together with the public spirit with which they are conducted, having a fair consideration for the welfare of the workmen employed, and other questions involving rather their duty to society than to their own personal profits. All such conditions are eminently fulfilled by the Vienna Brick and Building-material Company. First they have the Pension Institute of the Company, which has now a capital of 52,000*l.* The receipts for the first half of the year 1872 were as follows:—

	fl.	kr.
Contribution of the company -	5,000	0
Regulation deductions from employées	1,007	99
Interest on capital - - -	1,192	47
Arrears paid - - -	0	60
	7,201	06

The payments from July 1st to December 31st were:—

	fl.	kr.
Pensions - - - -	408	0
Sum written off - - -	26	23
	434	23

By the rules of the Pension Institute not only the men but their widows and orphans under certain conditions participate in its benefits. There is also a building club connected with it.

The rates of allowance for pension are as follows :—

From	10 to 15	years' service	$\frac{1}{3}$rd	of full pay.
„	15 to 20	„ „	$\frac{3}{8}$ths	„
„	20 to 25	„ „	$\frac{4}{8}$ths	„
„	25 to 30	„ „	$\frac{5}{8}$ths	„
„	30 to 35	„ „	$\frac{6}{8}$ths	„
„	35 to 40	„ „	$\frac{7}{8}$ths	„

Besides these admirable arrangements there is also—

1st. A sickness and charitable club, which in 1872 stood thus :—

	fl.	kr.
Contributions from the Vienna establishment - - - -	16,288	97
Contributions from the seven country works - - - -	10,121	14
Total -	26,410	11

2nd. A kindergarten; and

3rd. A hospital with branches at the other works which are situated in the following places :—Laarberg, and Laarwald, Leopoldsdorf, Guntramsdorf, Biedermannsdorf, and Vösendorf, and in Hernals. It will be at once admitted that in face of these facts this admirably conducted, and vast concern was fully entitled to the highest award which could be given by the jury.

The firm previously alluded to as being *hors concours* is that of Herr Paul March, of Charlottenburg, by Berlin. This establishment was founded in the year 1836 for the manufacture of ornamental terra-cotta for building and decorative purposes, mosaic and encaustic tiles, and stoneware vessels for manufacturers. It now employs nearly two hundred hands and a twelve horse-power steam engine, and is excelled by no other manufacture in the beauty and excellence of its products. The proprietor, Herr P. March, acted as reporter to the jury, and his great experience, and perfect disinterestedness were of the greatest value to the jury. His acceptance of this office of course excluded him from the competition. His chief exhibit was a magnificent exhedra, a beautiful raised garden alcove seat. The floor, two steps high, is of encaustic, or mosaic tiles arranged in patterns most harmonious in colour, and tasteful in design, the semicircular seat and its back wall are in glazed faiënce decorated with a maiolica course of fruit and leaves, and on the low wall is a series of most exquisite terra-cotta columns supporting a wooden trellis for vines, or other climbing plants.

Another important company which exhibited bricks and tiles of excellent quality was the Dithmersche Ziegel-und Thonwaaren Fabrik, formerly the works of H. H. Dithmer, Schleswig-Holstein. The company now employs about two hundred and thirty hands, and three steam engines of the aggregate power of fifty-five horses. These works were established as far back as 1782, and have enjoyed a considerable reputation for their klinker bricks, drain pipes, plain and ornamental roof tiles and ridges, &c., all of which were exhibited. One-third of their production is exported; of their hard klinker bricks which were the most notable of the productions exhibited, they manufactured in 1871 to the value of nearly 10,000*l.* The medal of merit was awarded to them.

The enormous development of chemical manufactories all over Europe has proportionately stimulated the manufacture of fire-clay into glazed stoneware, crucibles, and other pottery materials employed in them, and the extent to which such articles were exhibited was very great indeed; few comparatively, exhibited any unusual merit, but some of them, however, were of very high quality, and were highly commended. First in rank were Messrs. Doulton & Watts, of the Lambeth Pottery, and Messrs. Henry Doulton & Co., of High Street, Lambeth. The former firm exhibited chiefly in chemical pottery, terra-cotta for architectural purposes, and some beautiful artistic pottery. The chemical stoneware is made in various kinds of clay, &c. calculated to suit the purposes for which the vessels. &c. are required. Thus some have to stand a high temperature, others to resist the action of strong acids either in the liquid, or the gaseous state. They consisted chiefly of retorts and receivers, worms, and other parts of apparatus used chiefly in the preparation of nitric, sulphuric, and hydrochloric acids. Stoneware taps which were so finely adjusted that they worked as easily as if made of brass; these are for use also in vessels containing the strong acids and were shown in great variety. Also acid jars, connecting pipes, arms, evaporating dishes, pans, bowls, jars, funnels, percolators, and a great variety of small but useful articles. The *tour de force* in this direction was a complete stoneware pump of such large size that it could be worked by steam power. To those familiar with the magnitude of the manufacture of hydrochloric acid in our alkali works, and the difficulty of handling such a liquid, the full value of this extraordinary piece of work will be seen, and it appears they are made by Messrs. Doulton & Watts of different bores, from one and a half to six inches.

Another class of articles in unglazed stoneware was the furnaces for gold and silver assayers, dentists, photographers, experimental chemists, &c., exhibited in great variety, most of them strongly bound with iron clamps, muffles also, and crucibles of the same material very finely worked, and adapted for every purpose to which they are applied. Their finest crucibles, however, were those of plumbago, which although properly belonging to another class, in this instance fell to the pottery jury as being a part of the collective exhibition of Messrs. Doulton & Watts, and a special medal was assigned to them apart from their other exhibits, in consequence of their high quality; some specimens were exhibited which had borne from seven to ten outpourings of melted steel, an amount of use which only crucibles made of the most refractory plumbago carefully freed from every impurity could stand; some used in the lighter work of gold and silver refining, and even in brass founding, have stood as many as a hundred outpourings.

The artistic pottery of Messrs. Doulton & Watts consists of jugs, mugs, vases, bottles, salt-cellars, &c. in the ordinary brown stoneware in the old English style. And others in the style of Grès de Flandres made of a delicate grey coloured clay, ornamented with sgraffito designs, and in some instances by modelling in high, or low relief. Every article is true handwork, no moulds are used in any part of their manufacture, or decoration, therefore each object is the artist's own work, and so satisfactorily is it done that it leaves nothing to be desired. The colours used in the decorations are turquoise, violet blue, olive green, brown, and a beautiful plum colour. The nature of the material and the mode of firing prevent the coloured surfaces from being too smooth, on the contrary they run into beautiful mottled tints, and this increases the effect greatly without the artist's aid. The *sgraffito* designs are many of them very clever and spirited, and we understand are chiefly if not all the works of a female artist, Miss Barlow.

One large jug after the style of a grey beard, and two candlesticks in the Vienna Exhibition were the very best specimens of this ware which probably this century has produced. The large jug had around the upper part of its body, in a series of small sunk panels, groups of figures in high-relief representing scenes in the life of Christ, other parts of it were highly ornamented, but quite consistently with the nature and colour of the material. The two candlesticks were also fine art works; around the centre of each was a group of female figures altogether representing the ten

virgins. They were all acquired for the Edinburgh Museum of Science and Art. These beautiful articles in stoneware became known to the public in the Annual International Exhibition of 1871 in London, and excited great attention and admiration; so much are they now in favour that silver mountings are not thought too good for them.

The terra-cotta works of Messrs. Doulton were not of particular importance beyond the excellence of the material, which is very hard. The specimens shown were chiefly from designs of Lieutenant Ommaney, R.E., for portions of the building of the Royal Engineers' Institute, and consisted of arch-blocks for doorways, cornices, finials, spandrils, &c.

The manufactures of Messrs. Henry Doulton and Co., of Lambeth, were chiefly of kinds used by sanitary engineers, such as drain-pipes and junctions, drain-traps of all kinds, yard gullies and gully-traps, invert and junction blocks for sewers, air-bricks, and damp-proof-course bricks for foundations, patent surface conduits for irrigation, watercloset pans, urinals, lavatory fittings, kitchen sinks, &c. These are manufactured of two kinds of material; the first, common brown glazed stoneware, comprising specimens of drain-pipes for conveyance of sewage, and to act as main drains, also open channels to be laid on the surface, and connected with each other by socket joints for irrigating land; also sluice valves; also a great variety of drain traps, amongst which the most important seemed to be Mansergh's external house-protecting drain-trap used to prevent any foul air from entering a house. It consists of a double trap, and if by chance the body of foul air has force enough to pass through the water forming the first trap it must escape into the air. Hospital sinks, especially of the kind used at St. Thomas' Hospital, which is very large, and has a division so as to enable the washing and rinsing of clothes to be carried on, and kept separate from everything else.

The other kind of material used is a white stoneware called white queen's ware. Of this, specimens were exhibited in the form of lavatory, and closet fittings, some of the lavatory fittings being plain, and others decorated in gold and colours.

Very finely finished chemical vessels, especially a series for the distillation of mercury, received the medal for progress; they were from the manufactory of Fr. Ch. Fikentscher, of Zwickau, in the kingdom of Saxony, a large maker who employs 160 men and two steam engines working 55 horse-power; all his articles, which were numerous, showed the

same careful manipulation both in material and in their construction.

Similar to the glazed stoneware chemical vessels of the English makers are the excellent glazed retorts, and vessels for acids shown by J. K. Geith, of Coburg, who manufactures on a large scale, employing 114 men and a 40 horse-power steam-engine. He also received a medal for progress.

The great gas companies of Vienna, and Paris both manufacture their own retorts, specimens of which are exhibited; they are both of most excellent quality, and of the largest size. The Austrian company also manufactures other fire-clay goods on an extensive scale for sale, to which a progress medal was awarded, whilst the French company received a medal of merit for its gas-retorts. Another great public company, the Staats-Eisenbahn Gesellschaft, also manufactures clay goods, and the bricks exhibited as its produce were of so fine a quality as to be considered entitled to a progress medal. A like reward was given to the Österreichischer Verein für Chemische und Metallurgische Producten for their fire-clay wares chiefly made for use in their own works.

Gas-retorts of a very superior make were shown by the Société Anonyme d'Ardenne, Belgium, and Messrs. H. J. Vygen & Co., of the Prussian Rhine Provinces. M. Nicholas Joseph Dor, the Director of the Mines of M. L. de Laminare, at Ampsin, near Huy, in the province of Liège, exhibits a novelty in the way of retorts for roasting the ores of zinc. Instead of being cylindrical they are oblong in section, and about 4 feet in length; the texture of the material is very close and compact, the retorts being formed by hydraulic pressure. M. Dor claims that this method of manufacture ensures economy in working, and enables him to use larger retorts than could otherwise be employed in a zinc furnace. The jury were much impressed with the novelty, and apparent utility of the retorts, and gave a progress medal. A very extensive display of retorts for gas, furnace bricks, bosh-bricks, crucibles, and paving tiles was exhibited by the Société de St. Ghislain, Hainault, Belgium, from clay raised from their own quarries.

Messrs. Smal-Smal & Co., also of Belgium (Andennes, in the province of Namur), exhibited a very extensive display of fire-bricks for furnaces of all kinds of such superior quality that they received a medal for merit, the prices being considered low.

The only other noteworthy Belgian firm is that of André de Lattre & Co., of Seilles, Liège. They have a reputation for the high refractory power of their clay, and the care bestowed upon their manufactures.

Several other German and Austrian manufacturers deserve notice amongst the very numerous exhibitors of this class of goods.

First may be mentioned the—

Stettiner Actien Gesellschaft, Stettin, established in 1834 for the manufacture of tile stoves in the Dutch style, of, which in 1871 they made 860, of the value of nearly 10,000*l.*, employing 163 workmen, and an 8-horse power steam-engine.

2nd. C. Kulmiz, Saarau, in Silesia. The exhibits were gas-retorts, drain-pipes, and other fire-clay products of superior quality. Their works are large, employing 345 workmen and four steam-engines amounting to 60-horse power.

3rd. Nordmann Gebrüder, of Hazelbach, near Altenburg. Exhibited a good series of glazed fire-clay acid retorts, evaporating-pans, and other chemical apparatus. They employ both manual and steam power.

4th. The Greppiner Works at Bitterfeld, in Saxony, well known for their excellent designs, fountains, vases, and other sculptural works in fire-clay, and also for moulded works for building purposes, of which they turn out over eight million pieces annually. They employ over 290 men and eight steam engines amounting to 142 horse-power.

6th. Lederer & Nessényi, of Floridsdorf, near Vienna, who exhibited a great variety of admirable work in common brick-clay.

And 7th. The Prince Karl Oettingen-Wallenstein, of Konigsaal, Bohemia, exhibited good glazed, and unglazed drain-pipes and fire-clay gas-retorts.

As might naturally be expected the exhibitors of earthenware stoves were numerous, and their productions very various in quality from the cheapest to the most costly. In excellence of workmanship, and beauty of design none exceeded the two in the Russian Imperial Pavilion. They were made by Signor Leopold Bonafede from the designs of Signor Monighetti in enamelled faïence after the antique Russo-Slavonic style, and to accompany them in the decoration of the Tsar's pavilion were several flower vases and ornamental dishes of great beauty. Nothing but careful drawings could give a fair idea of the admirable taste, and accuracy of

finish in the works of these accomplished artists. If I mistake not Sig. Bonafede was, and perhaps is, the Director of the Imperial Mosaic Fabric of St. Petersburg. Of course, the progress medal was awarded to him. Next in merit was the truly magnificent maiolica stove exhibited by Rörstrands of Stockholm, to this the jury also awarded a progress medal, which, however, was refused by the Swedish Commissioner for the very absurd reason, that a similar reward was not given to another Swedish manufacturer of very inferior merit. This is mentioned out of justice to Rörstrands, and as an unique instance of its kind. The stove is of large size, fully eight or nine feet high, and is the exact counterpart of one shown by the same firm in the Copenhagen Exhibition of last year, and now in the Edinburgh Museum of Science and Art. The design is Renaissance, and it has an open fire-place with mantelpiece, and an alcove for vases; the colour is a leek green, not uniform, but splashed, having a very soft and agreeable effect. Two magnificent candelabra, each for about 20 candles, in the same material and made to match, were placed beside it; as a whole, it was probably the most extensive ceramic work in the exhibition.

The next manufacturer in point of importance was Bernhard Erndt, of Vienna, who showed a variety of maiolica chamber-stoves all characterised by excellent construction, and tasteful decoration. The other exhibitors of stoves of sufficient importance to obtain the merit medal were—

1st. Dubsky von Wittenau, of Pilsen, whose well-made large stoves were beautifully glazed; the white glaze especially was of unsullied purity and evenness over the whole surface.

2nd. The Stettiner Company, of Stettin, whose exhibits were chiefly noticeable for their very perfect construction and simple good taste. The firm has already been mentioned in connexion with its fire-clay goods, which are its chief manufactures.

3rd. The "Meissener Ofen and Chamotte-Waaren Fabrik Meissen," in Saxony. This is one of the largest manufactories of stoves on the Continent, making annually about 3,000, which are sold in Germany, and Austria. Many are of plain and unpretending designs, but the best ones are characterised by very high artistic taste. This establishment employs 270 men and a 15 horse-power steam-engine. It has only been in operation since 1865.

4th. Hugo Jelinek & Co., of Pilsen, who manufactures a large proportion of the stoves used in Austria; their plain white ones were on the whole the best they exhibited.

5th. R. F. Schröder, of Potsdam, exhibited stoves in enamelled pottery of a much more artistic character. The production of this firm is not large, not exceeding 400 stoves annually, but the value produced is about 3,000*l.* They also make a great quantity of cooking utensils in pottery.

6th. Villeroy & Boch, of Mettlach-Luxemburg. This, probably, the largest firm in Germany, for the manufacture of clay-work, also produces a large number of chamber stoves of the best quality, and in great variety.

Two other Austrian exhibitors, who received the medal for merit, are also worthy of mention, viz., W. F. Somerschah, of Prague, whose stoves are of very characteristic designs, and have soft agreeable glazes very free from flaws of any kind.

And the Gebrüder Schütz, of Olomouczan, in Moravia, whose glazed stoneware stoves are in great request in most parts of Upper Austria.

Of encaustic and coloured floor-tiles and glazed mural tiles the exhibitors were comparatively few, but although England so long held the lead in this manufacture, she has now some formidable competitors, notably so in Herr Paul March, of Charlottenburg, previously mentioned. This maker, and other continental manufacturers, aim at quieter tones of colour, and for mural decoration lighter and more cheerful colours, and the effects they produce clearly prove they are right. One of our English makers has taken a step in this direction, and it is impossible not to see in the mural tiles of Mr. Robert Minton Taylor, a fitness for domestic decoration which we have not been accustomed to hitherto. Our makers have aimed at startling effects, striking colours, and strong glazes. They must take a lesson from abroad, and they will learn that the quiet unobtrusive colours of our neighbours please best in the long run.

Diploma of Honour.

The enamelled tiles of Messrs. Mintons' were very fine, and the jury fully considered their great merits in awarding to their collective exhibition the highest reward in their power.

Medals for Progress

were awarded to Messrs. Minton and Hollins, whose works are too well known to need special reference.

And to Senhor Nolla, of Valencia, in Spain, whose manufactures were exceedingly good. Herr March, we previously mentioned, was *hors concours* in consequence of his being reporter to the jury.

Medals of Merit

were given to two other Spanish firms—

Senhor Manuel de Soto, of Seville, for Azulejos, in the Alhambra style, and Senhor Bens Slevat, for moderately good encaustic tiles, the merit shown being in the effort to introduce a new manufacture into his country.

To Mr. Robert Minton Taylor, whose admirable specimens have been referred to above, and to Messrs. Villeroy and Boch, who also make encaustic tiles in their immense establishment, which will be more especially mentioned under the following head of—

Terra-cotta and Household Pottery.

The only exhibitor to whom was awarded a medal for progress in this division was Victor Brausewelter of Wagram, Lower Austria, for his tasteful building ornaments and fountains, many of which were in use in the grounds of the Exhibition.

The medal for merit was given more liberally. Those recipients of this honour best entitled to notice were, 1st, Raffaello Pagliacetti of Florence, for a number of charming half-life sized busts in a nice warm yellowish-red terra-cotta, more properly belonging to the fine art department, and rather more French than Italian in style.

2nd. Tolomeo Rondani, of Parma, for a great variety of tasteful ornaments for buildings, and for garden decoration, especially some fine vases in a bold effective style, showing a great advance upon those he exhibited in London in 1862. Signore Andrea Boni ought to have been in this list, but to the regret of his numerous admirers he has begun to spoil his works by polishing, and other art tricks which deteriorate instead of improve most art works and none more than those in terra-cotta, in which, at least, we look for an absence of mechanical tiresomeness.

3rd. J. von Schwarz. The manufactures of this exhibitor cannot be strictly called terra-cotta, but they cannot be classed with any other equally well. They consist chiefly of what the Germans call speckstein, a variety of steatite, or silicate of magnesia. The manufactory began in 1854, but was then confined to the manufacture of gas burners of nearly pure steatite, but in 1869 another process was added, viz., the admixture of steatite and fire-clay for similar purposes to terra-cotta. It is evident they employ some very first rate artists, for the statues, vases, and other ornamental objects exhibited were of a very superior character,

and from the large quantity of steatite in their composition they have a soft, delicate, and very agreeable surface. The life size statues at a distance gave the impression of being formed of a delicate grey-coloured marble, and are said to bear exposure to the weather even better than works in that material.

4th. Villeroy and Boch (of Mettlach, there are two firms of the same name). This great firm has been mentioned before, whatever can be done with clay they do, and do it well. It is because the writer was perhaps more struck with their terra-cotta productions than others that they are especially mentioned here. But the immense space filled by their exhibits contains everything in clay from a brick to a life-sized statue. Their works are at Mettlach in Luxemburg, they employ over 1,800 men, and seven steam engines amounting to 217 horse-power, and in 1871 their productions amounted to a value of 125,500*l.* sterling. They make largely of encaustic tiles, but those exhibited could not compare with the English, or those of Charlottenburg; the clay used evidently will not bear the necessary firing without warping, or cracking. The terra-cotta manufactures although wanting in warmth of colour were excellent as art productions, and are manufactured to a very great extent for architectural purposes, for which they are admirably fitted.

5th. The Widow Ibsen, of Copenhagen, whose fine imitations of what are called the antique Etruscan vases are now well known amongst us; and,

6th. The nephew of Franz Stiegerwald, of Munich, for vases, and other objects in the Pompeian style. Many of the specimens shown by this exhibitor were well designed, and all of them were well executed; both modeller and kiln master had done their duties well.

Maiolica, Palissy, and other Faïence.

The very fine work by the Rörstrand Company, of Stockholm, has already been noticed under the head of "Stoves," but the name of their principal designer deserves mention here, although no information could be obtained as to the part he took in the design of the beautiful maiolica stove and candelabra except that the forms, the colour, and fine glaze were equally entitled to credit. The name and address of the designer is E. Jacobson, Architect, Stockholm.

But of all the exhibitors in this division of the class,

Messrs. Mintons rank the highest; as a firm, however, they have to be taken not especially as manufacturers of maiolica and faïënce but as potters generally, and as it is inconvenient to divide their works, and distribute them under the heads of maiolica, faïënce, and porcelain; it is better to take the whole of their marvellous exhibition into consideration in this place.

It would hardly be disputed by any visitor to the Vienna Exhibition that the greatest ceramic display was Messrs. Mintons', and few who had the gratification of seeing it will ever forget it. The cost of its production was immense, and the credit it did to the character for enterprise, and art-industry of our country cannot be over estimated. As an individual exhibition I think it would be admitted by all, whether exhibitors, or not, that in the group of ceramic art, it had no rival in the exhibition, and what Englishmen have the greatest reason to be proud of is, that although in 1870 we had an international exhibition of ceramic art in which Messrs. Mintons stood pre-ëminent, yet in 1873 we could hardly remember the former after seeing the wonderful progress of the latter.

As our chief manufacturers, we feel a pleasure in saying that their productions were never discussed at the jury meetings; from the first their excellence was recognised, and the highest honour was instantly spoken of as their due. The reporter having been on this jury as vice-president had the pleasure of hearing that it was the universal feeling of the eminent experts assembled on that jury that there could be no discussion upon the question, and the first diploma of honour was awarded to Messrs. Mintons, when the jury had before them the most absurd regulation that only one diploma of honour could be awarded to each nation for each group. Afterwards, but not without much difficulty, and the especial assistance of Sir Andrew Buchanan, and other eminent members of the council of presidents, this regulation was set aside, and justice was done, if not to all, at least to a greater number of exhibitors. But previous to this there was no difference of opinion, but the most perfect unanimity, upon the award to Messrs. Mintons; on every other question respecting this high honour there was much discussion, and the battle for the few rewards of this kind which, it was understood would be given, was serious. The idea that only one could be awarded to one nation was uppermost in the minds of the jury, and led to great difficulties, which would not have taken place had mere merit been the point for determination.

The following notes embody the special peculiarities of Messrs. Mintons' manufactures in the Vienna Exhibition:—

Their manufactures are as remarkable for their excellence as for the variety of their productions. Excepting hard porcelain, which has however been manufactured by them for a period of four years, all classes of pottery, from the cheapest earthenware to the most delicately decorated china, are manufactured in their works, affording employment to more than 1,500 people. The manufacture of earthenware forms a most important branch; the table and toilet sets exhibited by their firm are neatly printed, and the variety of effects produced by an intelligent enamelling show to advantage the resources afforded by their cheap style of decoration. In the class of painted cream-coloured earthenware may be noticed the two sets of basket-pierced dessert plates with cupids, or children, by M. Boullemier, and also a quaint déjeuner with subjects taken from Don Quixote by the same artist. These and other specimens are sufficient to reconcile the most fastidious connoisseur with our earthenware as an excipient for decorative pottery. Another, and still more striking illustration of this is afforded by the imitations of the *fayences d'Oiron*, better known by the name of Henri Deux ware. This rare pottery has been imitated with the greatest success, and Messrs. Mintons' exhibit dozens of pieces in which these gentlemen have intentionally met all the difficulties of the most delicate and minute workmanship. The damascene work of the Saracens in the middle ages do not afford examples of a neater execution than those presented by their barometer, their candlesticks, biterons, and salt-cellars executed by Mr. Charles Toft.

Maiolica, such as is made in England, was made first by Messrs. Mintons as far back as the year 1850, and for the following 15 years they were the only manufacturers producing it. Before this we had no pottery which could stand the effects of the damp, frost, or changes of temperature, and considering that the wonderful resistance of this material to these various agencies is combined with fitness for receiving the brightest and the hardest enamels, we can understand the favour it has met with by the public. For large pieces in this material Messrs. Mintons have no competitors; a great many of them are exhibited. The two pairs of large vases of Chinese shape, one with the yellow ground against which branches of the peach tree are placed, and that with a black ground with green branches and snowballs, show the resources of our English maiolica when a showy and striking effect is desirable. In some cases the opaque enamels for-

merly used on this ware have given way to transparent-coloured glazes similar to those used by the celebrated Salifly, and in this class may be mentioned a stork fountain, and the oval jardinière supported by two mermaids. A set of framed slabs representing the seven ages executed from cartoons drawn by Mr. H. S. Marks, A.R.A., show that the body of Messrs. Mintons' maiolica may be used as the groundwork of the most artistic painting on pottery. A more recent innovation is the process for painting under glaze with a peculiar kind of colours such as to stand the high degree of temperature required to vitrify the glaze under which they are laid. Until recently the number of colours able to resist the chemical action of the materials used in the composition of these glazes were very few, and the advantage of having a full scale of colours which could not only resist, but also be mixed in a variety of ways so as to produce the most delicate tints was soon appreciated.*

Mr. Mussill has applied his talent as a painter in body colour to the production of various pieces, most of them on a red body, amongst which the pair of cylindrical vases painted with a kingfisher, and other birds were the best. Such are some of the transformations of earthenware when submitted to different processes. The list would be a longer one if we had to put down all the new things that might be done with this material, and comparing it with what have been already realised. Some people were convinced that on china only bright and pure colours could be fixed, and they seem to have been induced to endorse this opinion from the superiority of the colours to be noticed in the old Sèvres ware. However, the new ware made in imitation of the old Persian earthenware, or, at least, made on the same principle, must upset this notion. On this new earthenware can be employed glazes such as the turquoise, the plum colour, the blue, and the yellow, which surpass in brightness and richness any colour yet produced on china. The bright turquoise is the favourite colour, and Messrs. Mintons have exhibited with a variety of smaller articles large vases of Indian shape, some of which have been painted in black under the glaze so as to increase to a great extent the general depth of that colour.

In another class, that of the vitrified bodies, parian is that in which most recent progress has been realised. Messrs. Mintons, exhibit several Japanese ornaments in which this material is stained with new colours. Some very powerful, some delicate; the newest is that tinted in pale red, and

* Messrs. Minton presented a unique and complete collection of their manufactures to the K. K. Oesterreiche Museum, in the Stuben Ring, Vienna.

with this was executed the busts of the Emperor, and the Empress of Austria, and also four small statuettes. Messrs. Mintons' object in following their researches in that direction was to get a vitrified porcelain which could combine the colour of the ordinary terra-cotta with the advantage afforded by a vitrified body when it has to be cleaned. The realisation of the object they had in view they consider a great success, as it seemed an insuperable difficulty to maintain the iron, which is used for staining, in a defined state of oxidation at the high temperature necessary to vitrify that porcelain. M. Solon, who occupied an eminent position at Sèvres as a decorator in the style called pâte sur pâte, has used the coloured parian to produce the vases exhibited, and which stand certainly at the head of their ceramic specimens. The principal vase, which is decorated with the figure of Fortune drawing lots, which are represented round the vase by small cupids personifying the different gifts, is the most remarkable. Next to this is that pair which was exhibited in the building of the English Commissioners, on which Cupid is tamed, or chastised by a female figure of a masterly design. Then we must not forget the pair with the figures personifying hunting and fishing on a black ground, and a series of plates of the same colour with allegorical figures in their centre.

In china, or porcelain Messrs. Mintons had a specialty for enamelling on a rich turquoise ground in the style of the old Chinese cloisonné; they have produced in this way a great number of pieces, some of which, such as lanterns, jardinières, and bottles have been sent to Vienna, but more refined pieces of enamelling on that same surface are shown in a pair of straight vases decorated with white storks, by Mr. Aaron Green, and several vases painted with natural flowers by Messrs. Thomas Simpson & Pilsbury; these flowers are skilfully arranged, and brightly coloured. The painting of figures on china is well represented by a very large pair of vases of a blue ground on which Mr. Thomas Allen has painted the birth and toilet of Venus, and on the panels on the opposite side Mr. Mitchell has painted creditable landscapes. Some other vases with Watteau subjects, and several sets of plates with female heads, cupids in monochrome, or coloured subjects with children, are by Mr. Boullemier, who paints with spirit and at the same time with great delicacy. A novel treatment in gilding is shown in a set of thin cups slightly tinted inside with pink, and decorated outside with Japanese groups embossed in gold, these are by Mr. Leger. Last of all may be mentioned

the set of pierced baskets for a dessert service, which are richly gilt, and delicately perforated, and the pair of vases or lamp holders supported by two cupids which have been decorated by Messrs. Whitaker and Albert Wright.

(Along with the earthenware specimens and after the maiolica we ought to have mentioned the four sgraffito dishes by Mr. C. Toft) which were amongst the great novelties of this extraordinary ceramic display. The importance to which the works of Messrs. Mintons have attained is due, in the first instance, to the spirit of enterprise and good taste which has ruled over them from their commencement, and never more than at the present time. But much is due to the talents of those employed, and one of the most pleasing duties the juries had to perform was to award prizes in the form of Co-operators' Medals, to the artists employed in several of the most important manufactories. The following is a list of the Messrs. Mintons' employées who were so distinguished:—

Léon Arnoux, director of the art work.
Aaron Green, portrait painter.
Aaron Simpson, gilder.
George Leason, foreman of the clay department.
Thomas Longmore, modeller.
Henry Mitchell, landscape painter.
Alfred Reynolds, printer on pottery.
M. Solon, worker in pâte sur pâte.
R. Pilsburg, flower painter.
Charles Toft, worker in Henri Deux ware.
Thos. Allen, decorator.
Jno. Henk, modeller.

The names of the co-operators of other British firms will also be given; they are of special interest to our countrymen. The diploma of honour was awarded to Messrs. Mintons for their *collective* display, for it was quite impossible to say that any one branch of their work excelled another, the same perfect treatment of material, and decoration was equally apparent in their maiolica, their fine porcelain, their stoneware, and their tiles, and thus viewed collectively they had no equal in the exhibition, and they, and our other leading potters reflected more honour on their country than any other class of exhibitors, the advance they had made was apparent to all, and was most freely admitted by the foreign jurors.

In the artistic decoration of faïence M. Th. Deck, of Paris, has no superior; the range of his work is limited, but its excellence is so great that it would be an evil were be to be led from his strictly artistic work to commoner manu-

factures. It is hardly too much to predict that when time rolls on to the distant future, M. Deck's beautiful portrait dishes will be as highly prized as those of Orazio Fontana, or the other old Italian artists in maiolica whose beautiful works are now only beginning to be justly appreciated. The most noteworthy of M. Deck's works in the exhibition were four large shallow circular dishes about twenty-eight inches in diameter, each with a fancy portrait occupying the whole of the interior.

The subjects of two of these are beautiful female portraits the one called the "fair Hollander, with a rich purple background, giving a very striking effect to the delicately painted portrait. The other, a noble lady of the time of Henry II., with a background of yellow as rich as the imperial colour of China, attracted multitudes of admirers, and was purchased for the Edinburgh Museum of Science and Art. One of the others was bought by Mr. Colin Minton Campbell of "Mintons," a pleasing tribute of homage from one potter to the talent, and good taste of a brother in the art. In all M. Deck's works, especially in his reproductions of Persian faïence, there is full evidence of a perfect mastery of the materials combined with a masterly treatment, both in the colour and design of the decorations, which places them in the category of fine art of the highest character. His plaques for decorating furniture are exquisitely handled, but the glaze on some of of them has not stood the firing well. The chief of these plaques are four painted by Gluck, and are hunting scenes, which if painted on canvas, and hung on the walls of one of our academy Exhibitions would not fail to attract a host of admirers; the subjects are "a boar hunt," "a stag hunt;" going to and returning from the chase. Two others by Anker are marvels of success in the ceramic art, for they have probably never been exceeded in size, the figures being half-life size, and free from warping. This marvellous success is the more surprising because M. Deck's process of fuzing in all his colours involves the necessity for firing each piece at an intense heat for fully 18 hours. M. Arrleer has nothing to do with this part of the process, but he ought to be happy that his beautiful landscapes and other subjects pass into the hands of so thorough a master of the furnace as M. Deck, and are made to pass through the fire, not only unharmed, but improved in brilliancy and durability far above any similar works on canvas. As an exhibitor, M. Deck deserved and obtained the highest honour it was in the power of the jury to award him, but there was another qualification he displayed for which he could receive no reward but the pleasure of doing a right

thing; he set an example which it is to be hoped will have many copyists in future exhibitions. Conspicuously amongst the beautiful productions of his ateliers was placed a faiënce tablet, on which was enamelled the names of all his artists. Thus giving "honour to whom honour is due," and only taking to himself the credit which justly belonged to him.

A near neighbour to M. Deck in the exhibition, and an equally ardent lover of his art, in which, however, his walk is rather different, was M. E. Collinot, formerly partner with the late M. Adalbert de Beaumont in Paris, who doubtless from his personal knowledge of Persia gave that stamp of Orientalism to the productions of this firm, which since his death has in no respect retrograded. Whilst M. Beaumont lived we had the very best reproductions of the beautiful Persian style from him. To M. Deck must now be given the palm, for he has approached even nearer to the originals in that soft pearly white texture for which they are so justly celebrated. But M. Collinot, if he has not pursued that one variety to its greatest perfection, has greatly extended his scope and has tried his hands at every variety of Oriental faïence. So remarkably has he succeeded in imitating the delicate pencilings of the Satsuma-ware that the Japanese members of the jury could scarce believe they were not real, and the canopy over his allotted space, miserably small for so fine a collection, was supported on pilasters made up of plaques, each of which was an imitation of one of the many varieties of Chinese crackle. It is a great advantage to a country when men like Messrs. Deck and Collinot devote themselves to a specialty, regardless of all temptations to make inferior articles for trade purposes; they do honour to themselves, to their country, and to their art.

The greatest novelty in French pottery was the extraordinary collection of decorative plaques by the celebrated Parisian architect, M. Leon Parvillée, who has done more perhaps than any man to imbue his countrymen with a taste for oriental art; indeed so great is his eminence in this respect that he has been employed even in Turkey itself, and doubtless possesses more knowledge of Turkish art than most modern Turks do. His beautiful plaques, or large flat dishes are admirable specimens illustrating all the richness of colour and variety in design of the very best period of Moorish art; so rich and full is the impasto of enamel colours that the designs appear to be in relief. He lays claim to a specialty in the enamels used, stating that from their peculiar composition they will not run however highly they may be fired; so clear is the outline of the designs that

they almost have the effect of cloisonné enamels. As the works of a gentleman of a totally different profession to that of a potter, and as the result of a very perfect knowledge of the principles of oriental art, these very beautiful works of M. Parvillée were amongst the most remarkable in the exhibition, and as a proof of the high appreciation in which they were held scarcely a piece remained unsold at the end of the first week.

The French department was particularly rich in characteristic or national faïences of artistic, but inexpensive kinds. Those previously mentioned were of the higher class, and generally of costly workmanship, but those to which allusion is now made had the very great merit of being in excellent taste, and yet adapted to the wants of those possessed of good judgment, but not of great means. Amongst our own and more especially amongst the German potters it was only too evident that those who work for the luxurious produce works of taste, but they who administer to the wants of the multitude have but little taste themselves, and make no effort to stimulate it in the public.

First of these French exhibitors in point of merit were Messrs. Geoffroy and Co. (Loiret), makers of Faïence de France, reproductions, in fact, of the beautiful wares of the Rouen, Moustier, Nevers, Marseilles, and Gien manufacturers of the best period. All of them were very choice, and certainly very moderate in price. There has been for the last 10 years a growing taste in France for these purely national styles, and we should not be sorry to see it extend to our own shores.

Next in importance were the excellent Palissy wares of A. Barbizet (Paris), in great variety, but not equal to the reproductions of M. G. Pull, of Paris, whose perfection in this specialty is remarkable. He was only represented in the Vienna Exhibition however by his name being inserted in the catalogue, but otherwise he was not an exhibitor, which was a cause for regret. A new artist in the line was Th. Sergent, also of Paris, who had some very pretty things with some novelty of invention, and it was stated that he was the producer of all he exhibited, that is to say, the work of his own hands, his factory being so small that he employs no assistants, in this respect resembling the great potter himself. F. Laurin, of Bourg-la-Reine (Seine), also showed a number of tasteful designs in maiolica for decorative objects, such as vases, jardinières, bowls, &c.

M. E. Rousseau has long had a good reputation for his faïence painted in crude enamels, and as he calls them his

"terres vernissées," and he never exhibited better, but the prices were exorbitant, and he had a competitor in a neighbouring exhibitor, M. Claud Laurain, who only appeared some time after the opening of the Exhibition. This exhibitor caused quite a sensation by his charming vases, dishes, delicately and vigorously painted, usually with flowers, birds, and insects on a lovely soft dove-coloured ground, not uniform but clouded, not exactly in E. Rousseau's style, but to some tastes more agreeable, and not half the price. M. Laurain had the satisfaction of selling his wares as fast as they were unpacked.

Another worker in the style of the old French faïence is M. J. Aubry, of Bellevue près Toul (Meurthe), who had to place his beautiful wares in the annexe of the French department. They were very delicately decorated in the styles of Rouen, and Nevers. There were also some good pieces in imitation of Delft, and Venetian, but not so good as the French ones.

M. H. Boulenger, of Choisy le Roi (Seine), also showed some good specimens of maiolica, but his chief display was in stone-china crockery for domestic purposes, remarkable for cheapness and good manufacture, but not entirely from clays of his country. His opaque china, or stoneware is a mixture of the French clay known as terre de Montroux, Cornish stone, and kaolin. The domestic pottery was very pure in colour, and so cheap that good dinner plates are made by this firm at 4*s*. a dozen.

Amongst the manufactures of Austria were the products of two potteries at Znaim, in Moravia. Both exhibited extensively common domestic pottery, which was remarkable for its neat make and nice tasteful forms. The utensils were chiefly for cooking purposes, and were generally brown or brown lined with light yellow, or varied with yellow, and brown in some very simple pattern. The two firms were Alois Klammerth and Franz Slowak. Other Znaim potters exhibited the same pretty crockery, but these two in addition exhibited some very choice specimens of maiolica of a remarkable type, the designs being quite Slavonic. The best of them were secured for the St. Petersburg museums, a few also for the Edinburgh Museum of Science and Art. The forms were particularly good, and there was an indescribable quaintness in the decoration which was very pleasing. The colours were light and were applied with great delicacy. Alois Klammerth had the best specimens, and was rewarded with the medal for progress.

Many of the visitors to the Exhibition of 1862 in London will recollect in the French Ceramic Department the stand of Messrs. Gillet et Brianchon, of Paris, with its gorgeous display of lustred-ware. The firm is now J. Brianchon, *aîné*, and he showed a similar, and not an improved series in Vienna this year, and styles himself the inventor of the art of producing lustred ware. It has been in practical use in this country a greater number of years than M. Brianchon counts in his life, and in the old gold lustred Staffordshire pottery had a more legitimate development than in the harlequin hues which disfigure rather than adorn the more modern attempts at imitating mother-of-pearl, and other nacreous shells. It is a far different thing, and certainly much more worthy a potter's efforts, to restore the art of producing the glorious ruby lustre of the antique maiolicas; and already we have seen in this Vienna Exhibition indications that skilful and persevering artists are on the right track. Most remarkable in this respect are the works of Giovanni Spinaci, of Gubbio, in Umbria, who has set himself the task of restoring the art which once made his town's name so famous. In this his success is great, and connoisseurs will have to be careful in their purchases, or they will perhaps buy the works of the 19th century instead of those of the 15th. Another successful worker in the antique style of maiolica is Torquato Castellani, of Rome, son of Signor Alessandro Castellani, so well known in this country by the splendid collections he has sold to our national museums. The younger Castellani has tried to equal the beautiful colours of the antique maiolica by using the natural oxides instead of those produced by the manufacturers, believing that the old masters did so, and that to that cause is chiefly owing the perfection of their colouring. Certainly the success he has achieved warrants the truth of his hypothesis, for anything more nearly resembling the antique unlustred maiolicas it would be difficult to imagine. Every piece exhibited by the two last-mentioned exhibitors was eagerly purchased before the end of the first week of the exhibition. The Marquis Ginori fulfilled his accustomed part in this Exhibition, and as on all former occasions produced an extensive and costly assortment of his manufactures, but he shone most in a new walk, and like Signors Spinacci and Castellani showed beautiful works in the style, and colours of the old maiolica painters. His ruby lustres and dark purples were particularly brilliant and pure, but in his old Capo-di-Monte style there was an evident falling off. It was overdone, and the eye gladly turned away from its groups of uncomfortably

grouped nudities to the repose of his quieter and more beautiful maiolicas. One large painted vase, nearly four feet in height, covered with a landscape representing a prairie on fire with a stampedo of horses, buffaloes, &c., was very fine as a picture, but the subject was unsuitable to a vase.

Three other firms, imitators of antique maiolica, Angelo Minghetti and Sons, Pasquale Antonibon and Son, and Count Annibale Ferniani, of Faenza, exhibited some exceedingly good specimens. They also showed some good work after the old styles of Nove, and Vicenza. But still more meritorious were the objects exhibited by the Cavaliero Farina and Company, which were original in character and design. Some pieces, notably a large pair of vases of a delicate buff colour, with designs in a burnt Sienna colour, had the rich picturesque effect of the best old sgraffito de Padua, without being imitations of it. Their beautiful toilette table in faïence was one of the finest works in this material in the exhibition. Their Medal for Progress was well earned. In the Portuguese court the Palissy ware of Emanuel-Cypriano-Gomez Mafra attracted much notice, and was thought worthy a medal of merit. It was bold in execution, and good in modelling and colour, but it wanted refinement. The manufacture is carried on at Caldas du Rainhu, province of Leiria. The curiously quaint pottery of Turkey was exhibited in considerable quantities, generally rude in its design. It was often fine in colour, and many pieces exhibited great technical skill. This was especially the case with the pipe-bowls from Constantinople, of which there were numerous exhibitors. The faïence of Nichané of Broussa (Turkey in Asia), was on the whole the best. A curious and very interesting collection of Moorish pottery especially rich in the fine cobalt blue so skilfully used by the Morocco potters, was exhibited by Dr. Maximilian Schmidl, who, availing himself of his position as Austro-Hungarian Consul in that country, has got together a collection which is of considerable value, as it represents every kind of vessel in the soft friable pottery of Morocco, and every different style of decoration, from the really refined moresque to the bizarre mixtures of green, yellow, and blue enamels and red sealing wax. Some very good drinking cups, &c. in imitation of the old German and Flemish grey and brown stone wares, were exhibited in the German annexe by Auguste Saeltzer, of Saxe-Weimar. Many were mounted in pewter, and had all the quaintness of the old forms. They were, however, dear in price, and far

inferior to the similar productions of Messrs. Doulton and Watts. There were a few specimens of the same kind of ware, imitations of old Greybeards, and flagons in the grand pavilion of the Royal Berlin Porcelain Factory, which were very choice, and after fine models.

The special manufacture of Wedgwood and Sons will close these remarks upon the pottery allied to faïence and maiolica; a definition which it has not been easy to keep to, and which, as a group, has rather the merit of convenience than anything else. Messrs. Wedgwood made a large display in the British division. It would hardly be possible in an exhibition where their pottery appeared, to pass it without mention, for it has long held a most enviable position in the modern history of ceramics, but there were upon this occasion no novelties whatever shown, and some disappointment was felt that a greater effort was not made to sustain the character of the famous Wedgwood ware. Some compensation, however, was made in their white ware, which lately has engrossed much of their attention, in consequence of the firm having had the advantage of the talents of the clever sketching painter, Léssore. Sad to say, however, such charming pictures as those on the plaques exhibited and on some of the white table services can hardly be looked for again from the same hand, for it is said that M. Léssore has suffered much from weakness of sight and is now unable to work. His method of fusing his enamels under the glaze has had many admirers. M. Beau, an excellent artist of the same school, is also engaged by the Messrs. Wedgwood, and several of his maiolica vases were of high merit.

Of the exhibitors of porcelain there were very many, and for convenience they will be mentioned in the order in which they were arranged in the Weltausstellung, beginning with Great Britain, at the western extremity to Japan, at the extreme east of the building. Having already spoken fully of Messrs. Mintons' porcelain, whilst on the subject of their other specialties, "The Worcester Royal Porcelain Company" comes first, and a most magnificent display it made. At no international exhibition hitherto has any individual firm or exhibitor produced so many novelties of a high order. First amongst them were the so called Worcester enamels, *grisaille* on *bleu du Roi*, after the style of the enamels of Limoges. Mr. Binns, whose excellent taste and thorough knowledge of his art has sustained, nay more, has raised the high character of the Royal Porcelain Works, is the originator of this beautiful style on porcelain, to which it is

peculiarly well adapted. The first specimens were produced in 1854, and were so highly commended by the late Prince Consort, that Mr. Binns was encouraged to proceed, and the beautiful specimens exhibited in the Paris Exhibition of 1855 were the result. Other choice specimens were exhibited in the London Exhibition of 1862, and a few more in Paris in 1867. They reached their greatest perfection in the Annual International Exhibition of 1871, when those wonderful triumphs of the potter's art, the pair of vases which Mr. Binns, with laudable pride, delights to call the National Vases, were exhibited. The designs for these really marvellous works were by Maclise, and represent on a flat surface, given by the specially designed forms of the vases, some of the chief incidents in the history of our country, derived from a study of the Bayeux tapestry. Mr. Bott, the artist, worked two years at these vases, and it was chiefly to his careful pencil and refined classical taste that the success of this costly experiment is due. To him these vases were the highest aim his life had known, and he died just as he finished them; fortunately others took from him this particular taste, and we may hope for good works of the same kind, but hardly such very perfect ones. It was too great a temptation to send them to Vienna, and although previously exhibited the jurors were delighted to welcome them there, and do them honour. There was a beautiful ewer and dish by the same hand, also decorated with subjects from English history.

After these highly artistic productions the most interesting specimens from Worcester were the Japanese art on ivory porcelain. This was so great a novelty that it took all by surprise, and none more so than the two Japanese jurors, who were never tired of declaring their admiration for them. It is a happy adaptation of that very delicate paste which Mr. Binns introduced in 1856, and which in 1862 was exhibited by the Worcester Company in a number of delicately beautiful things quite Raphaelesque in taste, which eclipsed the Capo-di-Monte of that time and since. Some of it was also a little like Buen-Retiro, but was too soft for that style, which in really genuine specimens is more remarkable for vigour than any other quality. There are those who despise all oriental art; they will soon be fewer in number, for as time goes on, and our knowledge increases, the æsthetical tastes of the whole human race will be studied, and not the whims and fancies of individual men. Latterly not a few men of good taste have been startled with the elements of real beauty to be found in Japanese art. The talented

director of the Royal Porcelain Works has been one of the first to appreciate it, and he must feel a great gratification that his good judgment met with such a great success in Vienna, for every piece was sold as soon as the public gained admission.

The introduction of a style so different required much courage, and great care that those who could really appreciate it and communicate their sentiments to others, should not be disappointed. Close study of Japanese art was therefore necessary, but this was difficult, for it had not been warmly appreciated, and our great national collections are singularly deficient in examples. The reporter believes he is right in saying that Mr. Binns was chiefly indebted to the extraordinary collection made by His Royal Highness the Duke of Edinburgh for his best examples. Had he had access to the grand Japanese collection of Mr. Jas. L. Bowes, of Liverpool, he would have found a mine of wealth in this direction. Fortunately there is a harmonious feeling amongst those employed in the Worcester works, and a taste taken up by the director is sure to be received warmly by the artists, and when we look at such exquisitely modelled and decorated specimens as those sent by Messrs. Hadley and Callowhill and their co-workers to the Vienna Exhibition, we can only envy Mr. Binns the power he has in producing such objects of beauty.

The jewelled porcelain of Worcester, of which one lovely specimen was exhibited, and instantly purchased by the Earl of Dudley, is entirely different from the jewelled porcelain of Sèvres, which latter is decorated with glass jewels obtained from the makers of those objects, who produce them by dropping minute drops of the various coloured glasses on thin plates of metal. These are fixed in their positions on the porcelain objects, in the last firing in the enamel kiln, by the aid of a little flux.

In the Worcester specimens the imitations of stones are produced by a much more tedious and more legitimate process. After the design is drawn on the glaze, the enamel colours are dropped on in a liquid state and fired, and they are then gradually raised by repeated applications of the colours, succeeded by repeated firings. This work requires the greatest nicety, first in the drawing and afterwards in the just apportionment of the colour to produce perfect regularity in the pattern and in the sizes of the jewels. The first exhibition of this beautiful work will be well remembered by those who examined the porcelain in the Paris Exhibition of 1867. It consisted of a superb

tête-à-tête service, presented by the city of Worcester as a wedding gift to the Countess of Dudley. The cup and saucer in the Vienna Exhibition were the same in design; a gold ground covered with raised jewels in beautifully symmetrical order. The *mat* of the gold is, like all of the best Worcester gilding, very rich and solid. Mr. Ranford is an artist in gold, who has for a long time done great credit to this manufactory. Worcester has for a long time enjoyed a great reputation for its beautiful Persian turquoise enamel colour, and the last new application of it has been in combination with a terra-cotta colour, many specimens of which were exhibited. Its novelty is likely to create a good sale for it for some time to come, and it is a pleasing relief to the violent demand which has prevailed for some time for common ornamental wares with nacreous lustres.

The following artists in the Worcester Porcelain Works were rewarded with co-operators' medals:—

Messrs. E. Bejot, painter in Japanese style.
Jas. Callowhill, painter in Japanese bronze.
Thos. Callowhill, enameller in the Limoges style.
Edward Probert Evans, Manager of Clay Department.
James Hadley, modeller.
J. Rainford, gilder.
J. Rushton, figure-painter.

But the chief worker at the Royal Worcester Porcelain Works is the director himself, Mr. R. W. Binns. Whether in striking out novelties, encouraging real talent amongst his co-operators, or striving to make a great concern a financial success, this gentleman is without a superior, and certainly the great eminence of this old establishment at the present time is due entirely to his remarkable aptitude for his profession.

Messrs. Copeland and Sons complete the group of British fine art potters, of whom we are so justly proud, and it is a remarkable thing that these great firms all differ essentially in their styles, and each has a specialty in which it stands unrivalled. If Messrs. Mintons cannot be approached in their maiolica, or the Royal Worcester Works in their Limoges and Japanese styles, so neither can Messrs. Copeland be surpassed amongst English potters in their Parian, which was, in fact, the creation of their firm, when under the late Alderman Copeland, and has introduced a new era into the history of the Ceramic art. The late eminent sculptor, Jno. Gibson, R.A., said that after marble, parian came next in order as the best material for

statuary, but this is only the case when it is handled with a skill equal to that we see exercised in the works of the firm now under notice. For the shrinkage of the material in firing is remarkable, and has to be calculated with a nicety which is little dreamed of by those who only see them in their perfected state. Messrs. Copeland have the good fortune to have a superintendent whose skiil is unrivalled in these matters, and Mr. Abraham's name is quite identified with their manufactures. Some of their parian works were very telling, especially "On the Sea Shore," "Master "Tom," and "Storm," from models by Mr. Durham, R.A., which deserve the highest praise for their vigorous and truthful treatment. The more classical conception, reproduced from Monte's "Infancy of Jupiter," is exceedingly fine. It represents Amalthea playing with the infant god, whilst the she-goat is standing by ready to afford him nutriment when required. "Spring" and "Autumn," two prettily conceived statuettes by the same artist, and two fancy busts by Mr. Durham, R.A., designed for the Crystal Palace Art Union, made a very fine display of parian. In their other works in porcelain, Messrs. Copeland were not behindhand. They have long been famous for the delicacy of their material the high finish in its technical manipulation, and especially its artistic decoration. There were some very beautiful vases, glowing with beauty, from the well-known pencil of Mr. Hurten, whose flower and fruit painting is perfection. Some pretty Moresque enamelling, on vases, by Mr. Ball, one of their oldest and best artists, were novelties in their way, and some Sèvres shaped trays, nicely modelled, decorated with charming figure subjects by Mr. Besche, were regarded as works of the highest merit of their kind. Two vases jointly decorated with "Watteau" subjects by Messrs. Besche and Hürten; the former artist has a *fête champétre* on one side, whilst the other glows with Mr. Hürten's lovely flowers, these were amongst their finest works. This firm was also very successful in many beautiful specimens, in which the Chinese and Japanese styles were adapted with nice taste to the European articles.

The diploma of honourable mention was given to Mr. G. Jones, of Stoke-on-Trent, for some good representations of maiolica and Palissy ware of a comparatively cheap kind; also some cleverly painted porcelain plaques, with oriental subjects by Mr. Tayler, who certainly deserved a co-operator's medal, and doubtless would have had it had his name been forwarded to the jury.

Messrs. T. C. Brown Westhead, Moore & Co., of Cauldon Place, Hanley, Staffordshire, were unsurpassed in

their fine white earthenware for table use. The immense export business done by this firm to nearly every part of the world shows the wide appreciation of their manufactures. Plates were broken for the jury, who were much pleased at the hardness of the material and its pure white vitreous fractures. For perfection of material and excellent workmanship displayed in all their wares, the medal of merit was unanimously awarded. They also showed some good specimens of decorative pottery.

As dealers were excluded by the rules of the jury from any participation in the prizes, it is only fair to mention such as by their good taste brought together for exhibition such collections as did honour to the commerce of our country. Foremost amongst these were Messrs. A. B. Daniell & Son, of 46, Wigmore Street, whose beautiful display of porcelain, maiolica, and glass added much to the interest of the Exhibition, for they had selected the very best specimens of our best makers. The same may be said of Mr. John Mortlock, of 203 and 204, Oxford Street, London, whose collection contained some of the finest productions of Messrs. Copeland, Minton, and the Worcester Porcelain Company.

Before leaving the English section it may be mentioned that some very beautiful things in maiolica and art tiles were shown in the villa of the Royal British Commission; they were considered by the jury well entitled to a reward, but the "questioner" did not give the proper information regarding their manufacture to enable them to decide if Messrs. W. B. Simpson & Sons were the actual manufacturers, or the agents for some other firm. Moreover, the art tiles, which were very fine, were set in a chimney-piece, which was held to be furniture, and consequently belonging to another section.

Spanish Porcelain.

Spain had very little to show in porcelain; it is hard to say for what reason, for in 1862 the firm of Messrs. Pickman & Co. exhibited some excellent specimens. On the present occasion they showed a considerable quantity of very deteriorated taste. This is the less explicable, for in the manufacture of enamelled, and especially of encaustic, tiles, to which reference has already been made, the Spanish manufacturers show signs of progress, and in their common pottery excellent taste is shown, especially in that from the old home of the Hispano-Moresco ware, the Balearic Isles, from whence biberons, and other clay vessels of much beauty of form and decoration were sent.

Portuguese Porcelain.

The large manufactory of Senhor Ferreiras-Pintos Bastos, of Ilhavo, province of Aveiro, which has been in operation ever since 1825, employs 150 hands, men, women, and children, besides a 12 horse-power steam-engine, and professes to have all its arrangements in accord with those of the works at Sèvres and Dresden, nevertheless devotes itself only to a low-class style of manufacture. This is to be regretted, because if only a few good things were produced for the persons of taste in Portugal, who are quite numerous enough to encourage a spirited manufacturer, such works would begin to exercise an influence which would in time be of great benefit to the whole country. At present the manufactures of this large concern lack both taste in decoration, in form, and in everything. As remarked under "Spanish Porcelain," the same matter for wonder exists, for so much more taste is found in the Portuguese faïence, notably in those of Senhor Mafra, and Senhor Barlou of Lisbon.

French Porcelain.

The Diploma of Honour was, as a matter of course, awarded to the National Manufactory of Sèvres, certainly not for what it has done in the Vienna Exhibition, but for what it has done for the world in times past. It was a mistake that the productions of Sèvres were separated from the other French ceramics, and placed in the fine art department. For the specimens exhibited certainly showed no indications of progress over what we have seen in many previous exhibitions. Every lover of the beautiful art which exercises such marvellous power in refining the taste of the masses, when skilfully exercised, must regret anything like a decadence in Sèvres, and we do not believe there is any decadence, it is only a political interruption. A nation which has the sense to see the value of such a manufacture, a nation which supports a professor in ceramic technology, will not permit it to decay; it may be interrupted, and it may take a more desirable course, namely, to let it assume its proper position amongst private enterprises. The latter is no doubt the tendency, and there were in the Vienna Exhibition unmistakeable evidence that this is the better course. Still it must not be lost sight of, that the exquisite taste so common amongst the French potters is due to the fostering influence the State establishments have had in France, and

if these are entirely thrown aside there may be a very lamentable decadence. Besides the National Porcelain Factory, that of Messrs. Ad Hache, et Pepin Lehalleur Frères, Paris, also received the diploma of honour for the superiority of their porcelain for general use, and also for the excellence and cheapness of their machine-made plates and dishes. It was stated that of these plates, which were beautiful as to form and lightness, 800 per day could easily be made by one man aided by three boys. There was a nicety of finish in all the services shown by this firm, and a good taste in the ornamentation, which was worthy of the eward, although they showed nothing which could be regarded in the light of a *tour de force*, but only what seemed to be the general stock of the establishment.

M. J. Brianchon has already been noticed for his lustred wares, which are on porcelain as well as faïence. The statuettes in tinted *biscuit* ware of Messrs. Vion and Baury of Paris, were exquisitely modelled, but many of them of very questionable taste. Some of the clothed figures were remarkable for their expression and clever attitudes; the formatore of the establishment must be a man of genius.

One of the specialties of the French workers in porcelain is the manufacture of flowers for decorative purposes, and even for use as bouquets, and although wanting in the vigour and sharpness which characterises the finer productions of the old Saxony artists, they nevertheless have a delicacy and prettiness peculiarly their own. Two exhibitors, M. Woodcock and M. Detemmerman, both of Paris, showed these porcelain flowers and bouquets in great variety. Those of the former were considered the better ones, but they each displayed excellent taste, and most delicate manipulation. M. Woodcock had amongst his curiosities of this kind some bouquets of violets and forget-me-nots so tiny and yet so perfect that they would be small enough for fairies, or for the button holes of the gentlemen at a wedding in Liliput.

Besides these the only other exhibitor of French porcelain entitled to special mention is M. Gosse, who exhibited very excellent apothecaries' ware in that material.

Italy.

With one exception almost the only Italian porcelain of any note was that of the Marquis Ginori, but as already stated it was in no respect superior to his efforts at previous exhibitions, and was surpassed by his efforts in a comparatively new direction, viz., maiolica.* This may appear inconsistent with the

fact that a Diploma of Honour was awarded to him, but the writer brought under the notice of his brother jurors the many political difficulties which had lately beset the Marquis, and especially the removal of the capital to Rome which had drawn away some of the best artists, also the persistent efforts he had unceasingly made to sustain this especial art in his country, and his employment against his own personal interests of 2,000 artisans, all of which was generously admitted by the writer's co-jurors, and considered to weigh heavily in his favour.

The exception made above is in favour of Cavaliero Giulio Richard, of Milan, who being a juror could not receive a reward. His choicest table ware in opaque hard porcelain was however exceedingly good, and was said to be made chiefly with Sardinian kaolin, of which his firm uses annually to the value of about 10,000 lira. He employs between 300 and 400 hands and produces annually of porcelain goods, the worth of 25,000*l.*

Denmark.

The porcelain manufacture has long been State sustained in Denmark, and the Royal porcelain works have done good service to the art. The beautiful service painted with the Flora Dannica will for ages to come be regarded as a wonderful work. But the Government has learned the wisdom of leaving to private enterprise what especially belongs to its operations, and although the still called Royal Porcelain Fabrik may cease to produce a few exceptionally fine works, it will, it is hoped, still maintain its high character for excellence, and produce good work in such abundance that the taste of the whole kingdom may be stimulated by it. This result is the more certain because it has a competitor which will run it very hard, namely, the factory of Messrs. Bing and Gröndahl, and few are now so ignorant of the principles of political economy as to deny that healthy competition is not more likely to succeed in trade than Royal patronage. The Royal Porcelain works are now conducted by Herr C. Falck, whose beautiful Copenhagen vase in the Rotunda excited great admiration. It was intended for the Scandinavian Exhibition held last year in the capital of Denmark, but could not be got ready in time. Some of the China clay used is imported from England, but the kaolin which gives its special character to the porcelain of Copenhagen is obtained from the island of Bornholm, and its quartz and felspar is procured from

Arendal in Sweden. The biscuit ware of these works has long been famous and has been in great favour in the form of statuettes representing the chief works of Thorwaldsden, it has however a cold bluish tint which is not in its favour. The firm of Bing and Gröndahl also manufacture art works in biscuit and in porcelain of excellent quality and design; so closely did both firms run together that the same reward, the Medal of Progress, was awarded to each. The general style of both manufactories is that of the old English, such as Chelsea and Bow, which if not actually copied has been very closely studied.

Sweden.

The two chief manufacturers of Sweden were both of them exhibitors of porcelain as well as faïence and maiolica. The firm of Rörstrand in both kinds exhibited largely; their unique maiolica stove and candelabras have already been mentioned, but their elegant table devices deserve equal commendation from the cheapest to the dearest, there being an entire absence of vulgarity of design, whilst some of the *tête-à-tête* services were so delicately touched with purple and gold scroll work and floral forms that they were suited for a queen's table. Their parian differed essentially from the Copenhagen biscuit, for unlike the latter it glowed with a soft and most agreeable warmth, whilst the tasteful ornamentation showed upon it with the best effect. But in parian the firm of Gustafbergs of Stockholm surpassed everything of the kind in the exhibition, and was the nearest approach to the exquisite ivory glaze of the Worcester porcelain of anything we have yet seen. Their table porcelain also was not inferior to that of the Rörstrands Company.

German Porcelain.

The two royal factories of Berlin and Meissen received by courtesy the Diplomas of Honour; the canopies under which their exhibits were displayed were quite royal, but the exhibits themselves were very disappointing to those who looked for art progress. Some of the specimens in the Berlin group had been exhibited before. Possibly the momentous events through which Germany has just passed withdrew the artizans, or diverted their skill to other purposes; certainly an excuse was needed for a display so deficient in taste, yet set forth with such imposing splendour. We know what these works have done and feel that only

temporary causes could throw them so far behind their proper position.

The firm of Dressel, Kister, & Co., of Passau, in Bavaria, exhibited a number of good figures and figure groups in coloured porcelain which gained for them a medal of merit. Their chief manufactures are for general table use, and are good of their kind; they employ a large number of hands and have very extensive works. Another large house, that of Carl Krister, of Waldenburg in Silesia, chiefly engaged in brick and fire-clay manufacture, also showed very good useful china-ware for which the merit medal was awarded to him. A similar reward was given to the Actien-Gesellschaft für Telegraphen-Bedarf for very superior insulators and other necessaries for telegraphic apparatus. A medal of progress to C. Tielsch & Co. for table porcelain of good quality and make. Medals of merit to Heinrich Kügemann, of Weisenau near Nürnberg for similar ware; to F. C. Müller for apothecaries' ware; to C. A. Pfeil for table ware, and to Messrs. Uechtritz and Faist of Wurtemberg for porcelain clock faces, a specialty for which this firm is famous. It was established in 1820 under the name of G. Faist and Otto Terefel, and now employs 285 artizans, a 16 horse-power steam engine, and three water turbines equal to 133 horse-power. They supply the larger portion of the porcelain clock faces for the German clock-makers, besides which they manufacture largely of stone china ware, and other goods.

Austrian Porcelain.

The fine decorative porcelain of Messrs. Fischer and Mieg, of Pirkenhammer near Carlsbad, was of a very superior quality; their large cylindrical vases, with picturesque street scenes most artistically painted upon them, were amongst the finest specimens in the exhibition. This firm uses a beautiful rich plum colour with great effect in decorating the lower parts of their large vases. It is a most exquisite mixture of crimson and purple, giving the idea of velvet by its softness and warmth of colour; it is peculiar to their house. The chief portion of their extensive display consisted of fine decorative pieces, but the useful was not forgotten; some of the table services were fit for an Emperor. Owing to the fact that Herr Mieg was one of the jurors, this firm, the first in the Austrian Empire, could not compete, but several of their artists were rewarded with medals. (See Appendix E.)

The medal for progress was awarded to the firm of Haas

and Cžižek, of Schlaggenwald, in Bohemia. Like the last they were worthily placed in the Rotunda. They only exhibited table ware, but of such pure material, such perfection of form, and such exquisitely tasteful designs that they had no superiors amongst the exhibitors. Austria is especially rich in the deposits of fine kaolin and other materials used in the manufacture, and since the abandonment by the government, of the Imperial manufactory in Vienna, private enterprise has been greatly stimulated, and many manufactories of note have thriven in consequence. That peculiar delicacy of pencilling which rendered the workers in the Imperial factory so famous, is not lost, but is spread about amongst the private firms, and certainly it exists in all its perfection in the works of Messrs. Haas and Cžižek. Some of the decorations had a Persian character, such as is frequently seen in their illuminated books, not however covering the pieces, but forming lovely border work.

Josef de Cente, of Vienna, amongst an extensive display of excellent art terra-cottas had also some stone china of fine quality made from Brenditz kaolin and the fine Schlaggenwald quartz. In texture it was not equal to the English, Brown-Westhead & Co.'s, for instance; but much of it was decorated with very good taste. The Elbogen Company, a large establishment, also received a medal for merit for their good useful table and household porcelain. So also did Herr Anton Tschinkel, of Eichwald, in Bohemia, for household porcelain and that variety of stone china which is there called ironstone (Syderolith).

In Austria, and in Vienna especially, a large number of persons, trained artists, work upon biscuit ware purchased from the manufacturers, and decorate either for the manufacturers, or on their own account. In the latter case they have small kilns and fire the pieces themselves. This sort of individual competition keeps up a most wholesome spirit of emulation, and is one if not the principal cause of the artistic excellence of Vienna porcelain works. Connoisseurs in this country have not hitherto fairly appreciated the extremely fine finish and good taste of what is now called the old Vienna porcelain; but as it is getting scarce and dear they will probably soon awaken to its merits. A number of the decorators exhibited in that capacity, and their names will be given with the co-operators in Appendix (E).

Hungarian Porcelain.

In all matters connected with the Weltausstellung, Hungary chose to be considered separately, and it is equally con-

venient to do so here, as only one is entitled to especial mention, that of Messrs. Fischer Moriz von Farkashâzi, of Herend, known only too well amongst collectors as the most successful imitators of almost every kind of porcelain one cares to have. Their cleverness in producing fac-similes of Chinese (back to the Ming dynasty), Japanese, Dresden, Sèvres, or anything else is marvellous. They were rewarded with a medal for progress? and they have a large business and a good export trade, supply many countries, even the United States, with fine old china of all periods, countries, and styles guaranteed equal to the original.

Russian Porcelain.

The Imperial Manufactory of Porcelain (St. Petersburg) received, and deserved, the diploma of honour, but there was some reason for regret, both in this and the glass section, that the Russian artists or the artists employed by Russia are adopting foreign models and styles. There is something so truly national, and at the same time pleasing in the true Russo-Slavonik, that it is a pity to displace it with bad imitations of other styles. There was just enough left of the old style to justify the award, but a little more displacement and a future exhibition jury will reverse the judgment. Nationality in art is the last point which ought to be surrendered. We know the want of it.

Greece, Turkey, Egypt, Persia, Roumania, &c. followed after Russia in the exhibition arrangement, but none of them displayed any porcelain.

Chinese Porcelain.

China came next, but the Chinese themselves did not exhibit, and this remarkable feature in the art manufactures of China would not have been represented at all had it not been for some collective exhibitions got together by Europeans interested in China. The first of these was a valuable and very interesting one sent by the Rev. Archdeacon Gray from Hong Kong, but it consisted chiefly of old specimens, many of great beauty and rarity, illustrating the history of Chinese porcelain manufacture. Another not less interesting, and in many respects similar, collection from M. Kopsche, Commissioner of Customs at Kin-kiang, had the additional value of containing also illustrations of the native materials and processes. Mixed up with the Rev. Archdeacon's collection was a small series of modern specimens from a maker, Hsu of Hang Kow. From information obtained

from the Chinese Commissioners it appears that the greater part of the modern Chinese porcelain so abundantly imported into Europe is made at King-teu near Kin-kiang and is enamelled, or painted elsewhere, and that the imperial yellow so much prized by connoisseurs indicates that it is a part of the annual tribute paid by the pottery districts to the Emperor.

A very large collection of modern China was exhibited by Messrs. Carlowitz, of Canton, most of it being of an ordinary kind. Mr. Gustave Overbeck had a smaller collection of superior quality, amongst which were some pieces of rare merit by special Chinese artists, three especially, Po-hing, Quong-hing, and Yut-ching, were awarded medals of good taste.

It may perhaps be noticed that this is the first mention in this report of a medal of good taste, and it will also appear strange that in a group like that of pottery and porcelain it was not very freely awarded. It was liberally awarded to many well deserving exhibitors, but was afterwards disallowed by the council of presidents in consequence of an absurd rule that no exhibitors in the same section could receive more than one medal, hence the relative values at first attached to the medals was in the end virtually abandoned, not by the jury, but by the council which revised the awards without knowing anything of the individual circumstances.

Japanese Porcelain and Pottery.

Japan offered a great contrast to China, the latter was entirely indebted to foreigners for any appearance made in the exhibition; Japan on the other hand had a numerous active, and highly intelligent commission appointed, and notwithstanding the great distance from their country to Vienna they made one of the most creditable displays of produce and manufactures exhibited by any nation. Amongst the latter, Japanese ceramic art was admirably and extensively represented, moreover it was classified after their own manner, which was as follows:—

1st. *Manshi Porcelain.*

Made in the Province of Guifou. Tea-cups with lids and saucers, after the Chinese and Japanese style, were shown in this ware, which was of ordinary quality, painted with oxide of cobalt in the common blue colour. It takes its name from the manufacturer.

2nd. *Sampei.*

Also named after the manufacturer, whose works are in the small island of Anadji (Anadji Sima), in the Province of Miodo. By this maker there were two very different kinds shown, differing more in appearance than in reality. His material seems to be of very fine quality, taking a beautifully soft smooth surface. The first and most distinctive sort has the light buff colour of the Satsuma pottery, but rather more inclining to egg yellow, and with a smoother glaze, and it is decorated much in the same style as that famous ware. In fact, it is used for imitating Satsuma, and is often sold for it in Europe. If it is borne in mind, however, that Sampei ware is porcelain, and Satsuma pottery, no such mistake will be made. His other kind is a brown and reddish-brown ware, which would by most persons be taken for pottery, but the fact is the base is porcelain, over which a red-clay slip is spread and fired, and then glazed. A slight examination shows that much skill is required to produce both these kinds of porcelain, for although very unpretending in appearance they are exquisitely finished. Teapots, and hibatchis or tea-infusers were the forms in which they were exhibited.

3rd. *Seto Ware* (*Porcelain*).

Made at the town of Seto, in the Province of Aidtsi, one of the great centres of the Japanese ceramic manufacture, employing in that town and its neighbourhood over 2,000 workers in porcelain and its decoration. It is ornamented in imitation of Kioto-ware, chiefly in blue, of which there were four magnificent circular dishes, also in red and gold, the red colour derived from native oxide of iron; this ware can only be distinguished from that of Kioto by being thicker and heavier, and altogether less delicately fashioned.

4th. *Banko-Yaki* (*Pottery*).

This remarkable ware, named after its inventor, is as hard as Wedgwood, but is very light. It is ornamented with richly enamelled flowers on a thick opaque soft glaze.

5th. *Kioto* (*Porcelain*).

Named after the city of Kioto. It has a great reputation in Japan, where the finest quality decorated in red and gold is very costly. There is, however, a considerable quantity

of Kioto ware of more ordinary kinds for general use; these vary much in style, colour, and workmanship. The red colour used like that of the Seto ware is native oxide of iron, but with a thinner impasto; the Kioto colour is richer, and has the inclination to that yellowish tint seen in vermilion, more marked than in Seto ware, whilst the gold has more body and brilliancy. This manufacture is limited to one quarter of the city. In another quarter is manufactured distinct varieties of pottery and porcelain, both classed as

6th. *Awata Ware.*

Both the porcelain and faïence have the same kind of buff colour as Satsuma, but paler. The style of decoration is much like Satsuma, but more distinct and more richly coloured. European gold and enamels are said to be used on this ware, and it is largely exported to Europe and America as Satsuma ware.

Besides these productions of two quarters of the city of Kioto there are other celebrated potteries in various parts of the province of the same name, chiefly famous for the manufacture of small figures and statuettes, of which a great variety was exhibited, some of them very finely modelled. Similar statuettes are also made in the province of Foukouoka.

8th. *Hitzen or Saga* (*Porcelain*).

This is the most important of all the manufactures of porcelain in Japan. It is made in the city of Arita, in the province of Saga. Some plates were shown over a yard in diameter exquisitely painted in Nankin blue under the glaze. These extraordinary pieces are partly fired in muffles, and notwithstanding their immense size they were beautifully true in shape. One gigantic vase was over five feet in height and of good form. Besides these large pieces there were others in great variety of style and colours, even some exquisitely delicate egg-shell cups and saucers which would require very slender fingers to handle them. The Japanese Commission were very proud of their Saga ware, and well they might be.

9th. *Kaga Ware* (*Porcelain*).

This is often wrongly called by English collectors Kanga ware. It is made in the province of Tshikawa, and is perhaps the best known of all the kinds of Japanese porcelain. Often

of the egg shell quality in thinness it is beautifully translucent, and almost invariably ornamented in red and gold, or in red only. It is never as thick as the Seto ware, or even as that of Kioto. The finest qualities exceed every other kind of porcelain in thinness and lightness, but they are rarely seen even in the best collections.

10th. *Satsuma* (*Pottery*).

This most famous of all the Japanese faïence is made in the department of Kagosina in various potteries belonging to Prince or Daimio, Satsuma. It is most distinct in character, and cannot well be mistaken by the practised eye, although the Japanese are fond of imitating it. The body, notwithstanding its soft look, is very hard, indeed it is half porcelain. Its colour is a soft greyish stone colour, not easy to describe. In its style of decoration it is quite unique. Flowers, birds, insects, and not unfrequently the favourite snow-capped mountain Fusi-yama are all freely employed, but so pencilled and so daintily coloured that they never seem to interfere with the neutral tint of the pottery itself. Occasionally large vases are surmounted with life-sized flowers beautifully modelled; the favourite chrysanthemum being always most prominent. At one time Satsuma ware fetched very high prices in Europe, and it was said that its rarity arose from an edict against its exportation by the Daimio. Now it is neither very rare, nor very dear, but the quality varies very much, and pieces of the best quality are as rare as ever. Moreover this seems to be the case in Japan as well as with us, for in the whole collection, not a small one, in the Weltausstellung, there was not a single piece of first-rate quality.

11. *Nagasaki* (*Porcelain*).

This is a very pretty variety made at Nagasaki, and very closely resembling Kaga ware in its delicate thinness and decoration, but on all the pieces exhibited there were besides the well known red and gold decoration, panels in blue, which had a pretty effect. The writer was told that this was a distinctive characteristic.

Like Austria, Japan has its association of painters on pottery and porcelain, who buy the articles in biscuit, and in their own houses enamel and glaze them. A collection was sent by this association, which has its head quarters at Yeddo, in order to show the special talents of its members. In many of the best specimens a kind of gold clouding was a prominent feature. It is a sort of avanturine-like sprinkling

of minute spots of gold, the more minute the more clever in their estimation. Mr. Binns of the Royal Worcester Porcelain Works, who lets no difficulties daunt him, showed some excellent efforts in the same direction, which greatly surprised, and astonished the Japanese jurors, who evidently thought it a specialty of Japan. The most artistic productions shown by the associated painters were some beautiful buff coloured vases of Kioto ware on which the designs were pencilled with a delicacy and freedom quite marvellous.

Altogether to the lover of pottery and porcelain, the Japanese collection was most interesting and instructive, and many medals were awarded.

In a distant pavilion in the Exhibition grounds there was an exhibition by a small State which is not very well known as a competitor in the race for fame in international exhibitions, and the chief part of this small exhibition was its ceramic manufactures. The small state was *Monaco*, and the objects were exceedingly beautiful and altogether unique, objects in the form of baskets and vases of flowers so true to nature that it was difficult to believe they were not real. The flowers had not the French daintiness of the porcelain bouquets of Messieurs Woodcock and Detemmerman, exceedingly pretty ornaments for a splendidly furnished dinner table, but they had the breadth of colour, and apparent texture of nature herself. They were a puzzle to all who saw them at first; then came the disappointment, they were simply painted by an exceedingly clever artist who has struck out a new path which will not be a very profitable one, for paint and pottery never agree. The medal for good taste was, however, awarded to him, and had he been able to have done the same work in enamel colours, he would have richly earned the diploma of honour.

The only other recipient of the medal for good taste, not previously mentioned, was Dr. Hunter, of Madras, whose efforts to train the taste of the natives in the Schools of Art which he has really created in the Presidency to which he was attached, deserve a much higher recognition from his country than the poor one the Vienna jury were limited to. The school examples, which were exhibited under every disadvantageous condition, half unpacked and so on, nevertheless excited the admiration of the skilled jurors and raised a feeling of regret that no other acknowledgment was within their competency.

In bringing this report to a conclusion I think it well to point out that in porcelain three countries stood unquestionably before all the rest. In my own individual judgment, but I hope without prejudice, I think the palm unquestionably is with our own country; with Mintons, Binns (Worcester), Copeland, and Wedgwood to look to, few will contest this. I next place Austria, for the works of Fischer and Mieg and Haas and Czižek are in their way so fine and perfect, that with them in my mind I have hesitated in putting my own country first. France certainly comes next and sustains her reputation not by the national works of Sèvres, but by the meritorious works of a private firm, Adolph Hache and Pepin Lehalleur Frères, who like the two Austrian firms mentioned have tried to introduce forms of beauty into every household.

In the production of encaustic tiles we still hold the foremost reputation, but Herr Paul March of Charlottenburg will soon make it difficult to retain that position if he can prove that that most beautiful of all the structures in the exhibition, his classical exhedra, is paved with tiles which are not only exceptionably beautiful but can be produced as cheaply as those of Minton and Hollins, Robert Minton Taylor, Maw, or Simpson. In decorative faïence, not forgetting the glorious display of Messrs. Mintons, which is not confined to that specialty, France is certainly triumphant. With her Deck, Collinot, Barbizet, Pull who was not at the exhibition, Aubry, Callias, Geoffroy, Rousseau, and last, but certainly not least, the learned and exquisitely tasteful Parvillée, she need not fear any competitors. Looking back only to the small exhibition of the Cours Central in 1868, her ceramic artists have made immense progress not only in the technique, but in the æsthetics of their art.

In terra-cotta works, in which Italy used to shine pre-eminent, she could not be considered either against Prussia or Austria. In Prussia Herr Paul March again sustains his country's reputation in this kind of work, not only for manufacture but also for beauty, and certainly there was no disputing that the next was the great Vienna Brick and Building Material Company.

In sanitary pottery, and in chemical wares, if we had none others in the British section than the two firms of Messrs. Doulton and Watt, and Messrs. Hy. Doulton & Co. we should have stood pre-ëminent; their practical work was the admiration of all the jurors, and whether it was their

cheapest ink-bottle with its convenient but simple spout, or their grand *tour de force*, the stoneware pump for acids, no praise seemed too great for them.

In taking leave of this subject, and at this particular point the reporter feels a pleasure in recording his belief that whatever errors his colleagues may be proved to have made in their awards, he can most confidently affirm that no body of men ever tried more honestly to do justice to all, irrespective of nationality, or any other difference, and although there were representatives of nations which had only just laid aside the sword, and which had been *politically* opposed to each other, no trace of any antagonism which could have arisen from such causes ever for a moment interfered with our deliberations. Much of this arose from the amiable character of our president, M. Guillaume, who was always able to smooth down any difficulties by his gentle, but firm manner of asserting that peace must be the grand feature of our deliberations. Another source of ease to the labours of the jury was the clever tact, and admirable linguistic powers of Dr. Eduard Schmidl, who acted as President to the section of Pottery and Porcelain, and also as general interpreter; in this latter capacity he gave an amount of satisfaction by his careful representation of the feelings of those for whom he spoke, which will never be forgotten by those who had the pleasure to be associated with him.

APPENDIX A.

The JURY which ADJUDICATED in GROUP IX.

PRESIDENT.

M. Guillaume, Member of the Institute of France, Director of the School of Fine Arts, and Member of the Council of the National Manufactory of Sèvres.

VICE-PRESIDENTS.

Herr Ludwig Lobmeyr, Imperial Royal Glass Merchant, Vienna.

M. Léon Mondron, Member of the Chamber of Commerce, Charleroi, and President of the Association of Glass Manufacturers of Lodelinsart, Belgium.

PRESIDENT OF THE SECTION FOR POTTERY AND PORCELAIN.

Dr. Eduard Schmidl, Civil Engineer, Vienna.

VICE-PRESIDENT.

Professor T. C. Archer, F.R.S.E., President of the Royal Scottish Society of Arts and Director of the Museum of Science and Art, Edinburgh.

REPORTER.

Herr Paul March, Member of the Chamber of Commerce, Charlottenburg, Prussia.

JURORS.

Professor Aimé Girard, of the Conservatoire des Arts et Métiers, Technical Chemist, Paris.
Herr von Arz, National Councillor, Olten, Switzerland.
Herr von Cohausen, Director of the Museums of Wiesbaden.
Herr F. von Dardel, Ober-Intendant, Cabinets-Kammerherr, Stockholm, Sweden.
Herr Franz Krause, Glass Manufacturer, Steinschönau, Austria.
Mr. Louis Hinton, Connecticut, U.S. America.
Gospodin Kroupski, Adjoint-Professor in the Technological Institute, St. Petersburg.
Professor de Luynes, Conservatoire des Arts et Métiers for Chemistry applied to Keramics and Glass, Paris.
Herr Ludwig Mieg, Porcelain Manufacturer, at Pirkenhammer, Austria.
Herr C. Muysken, Architect and Secretary to the Royal Netherland Commission.
K. Nôtomi, Commissaire of the 3rd class, Japan.
K. Ogata, Commissaire of the 3rd class, Japan.
Herr George Benedict v. Poschinger, Manufacturer, Frauenau, near Zwiesel, in Bavaria.
Signor G. Richard, Manufacturer of Porcelain, Milan.
Herr Angelo Saulich, Cement Manufacturer, Salzburg, Austria.
Herr Phillip Schoü, Manufacturer, Denmark.
Herr Ernest Szumrák, Director of the First Glass Manufacturing Company of Pesth.
Dr. Emil Teidrich, Engineer and General Secretary to the Vienna Brick and Building Material-making Company, Vienna.

ASSISTANT-JURORS.

Herr Bodmer-Biber, Zurich.
M. Clemandot, Civil Engineer, France.
M. Dubouchet, formerly Manufacturer at Limoges, Councillor of the National Manufactory of Sèvres.
Herr Wilhelm Jäger, Architect, Brunn, Switzerland.
Herr Wilhelm Zsolnay, Fünfkirchen, Hungary.

EXPERTS.

Messieurs Dognée, Tasson, and Clerfeyt, Belgium, and Professor Lambert Mining Engineer, of Louvain, Belgium.

APPENDIX B.

MANUFACTURES of CLAY comprising POTTERY, PORCELAIN, TERRA-COTTA, FIRE-CLAY GOODS, STONEWARE, &c. exported from Great Britain in 1872.

—	Weight in Tons.	Value.
		£
To Russia	17,377	21,370
Sweden	5,475	9,926
Germany	24,284	27,149
Holland	26,827	41,401
Belgium	2,831	4,774
France	13,387	17,448
Spain	3,432	4,913
Italy	5,346	6,705
United States—Atlantic	8,915	18,654
„ „ —Pacific	1,658	2,660
Foreign West Indies	3,929	5,005
Chili	6,220	8,421
Australia	4,858	9,265
British North America	11,105	14,847
British West India Islands and British Guiana.	27,713	23,911
Other countries	17,412	26,335
Total tons	180,769	242,784

Besides which china clay was exported as follows :—

—	Weight in Tons.	Value.
		£
To Russia	3,762	5,055
Sweden	3,669	4,053
Germany	16,286	18,622
Holland	15,773	17,473
Belgium	22,993	28,029
France	30,346	36,188
Italy	2,348	3,342
United States of America	6,331	9,927
British North America	1,577	2,115
Other countries	6,931	8,445
Total tons	110,016	£[illegible]3,249

APPENDIX C.

The following STATISTICS of CLAY are necessary to estimate the importance of British Manufactures.

Of Cornish kaolin or china clay the production in 1871 was - - - - - - - - 125,000 tons.
Of Cornish china stone used in the manufacture of stone china ware - - - - - - - 33,000 „
Of Devonshire potters' clay the production was - - 66,639 „
And of Dorsetshire clay there were exports to the following places:—

	Tons.		Tons.
London - - -	21,925	Brought forward	54,855
Runcorn - -	20,430	Swansea - - -	255
Goole - - -	2,265	Weston Point - -	235
Glasgow - -	1,625	Gloucester - -	215
Bristol - - -	1,180	*Quebec* - - -	200
Newcastle - -	910	*Vargo* - - -	195
Dordrecht - -	790	Stockton - -	185
Stockholm - -	765	Whitehaven - -	175
Hartlepool - -	735	Kirkcaldy - -	300
Bremen - - -	680	*Cartagena* - -	135
Sunderland - -	680	*Brussels* - - -	125
Liverpool - -	450	*Dunkirk* - - -	115
Hull - - -	390	*Bremenhaven* - -	115
Borrowstoneness -	385	Teignmouth - -	105
Ellesmere - -	370	Swanage - -	100
Leith - - -	365	Southampton - -	85
Copenhagen - -	355	*Caen* - - -	80
Llanelly - - -	310	Cardiff - - -	80
Grimsby - - -	245	Jersey - - -	45
Carried forward	54,855	Total tons -	57,600

APPENDIX D.

JURY AWARDS.

AWARDS MADE BY THE JURY IN GROUP IX., SECT. 2, TERRA-COTTA, POTTERY, AND PORCELAIN.

DIPLOMAS OF HONOUR.

FRANCE.

Cat. No.
39. Theodore Deck, Paris. For artistic decoration of faïence.
— The Sèvres Porcelain Manufacture.
45. Messrs. Adolphe Hache and Pepin Lehalleur Frères, Paris.

GREAT BRITAIN.

711. Messrs. Mintons, Stoke-on-Trent.
— The Royal Porcelain Works, Worcester.

ITALY.

Cat. No.
110. The Marquis Lorenzo Ginori, Doccia near Florence.

RUSSIA.

14. The Imperial Porcelain Works, St. Petersburg.

GERMANY.

117. The Royal Porcelain Works, Berlin.
118. The Royal Porcelain Works, Meissen, Saxony.
169–202. Villeroy and Boch, Dresden.

AUSTRIA.

370. The Vienna Brick and Building Material Company.

JAPAN.

Porcelain Factory at Hizen Arita.

MEDAL FOR PROGRESS.

Porcelain and Stone China.

213. Bing and Gröndahl. Copenhagen. Ornamental ware.
154. Cente, Joseph de. Vienna. Ovens, chimney pieces, terra-cotta vases, &c., stone china.
229. Fabrik Porzellan-Gräflich Thun'sche, Klösterle, Bohemia, Porcelain fired by wood-gas.
224. Falk, C. Royal Porcelain Works, Copenhagen.
14. Fischer, Moritz von Farkasházi. Herend in Hungary. Porcelain imitations of old styles.
177. Haas and Cžižek. Schlaggenwald, Bohemia.
49. Parvilée, L. Paris. Dishes in Persian style; pottery.
119. Tielsch, C., and Company. Prussia; porcelain and stone china.

MEDAL FOR MERIT.

Porcelain and Fine Stone China.

178. Actiengesellschaft Erste-Porzellan and Steinkohlen Industrie. Elbogen, Bohemia. Chemists' vessels.
127. Actiengesllesch.ft für Telegraphenbedarf, Berlin, for porcelain insulators.
97–100. Ahmed, Turkey. Earthern vessels.
33. Brianchon, J., Ainé. Paris. Lustre-ware.
372. T. C. Brown-Westhead, Moore, and Co. Hanley, Staffordshire. Fine stoneware.
707-841. Carlowitz & Co., Canton, for collection of china.
362. Copeland & Sons. Parian and porcelain, &c.
124. Dressel, Kister, & Co. Schwarzburg-Rudolstadt. Biscuit figures.
491. Fabrik "Gustafsberg." Stockholm. Porcelain, parian, and faïence.
44. Gosse. Paris. Porcelain apothecaries' ware.
— Gray, Archdeacon. Canton. Old china.
33. Greiner, Elias. Saxe-Meningen. China-ware.
— Klopsch, Mr. Customs Commissioner, Kiukiang. China collection of china-ware.
120. Krister, Carl. Waldenburg, Silesia. Prussia.
131. Kügemann, Heinrich. Bavaria.
123. Müller, Friedrich Carl. Prussian Saxony. Chemists and Apothecaries' porcelain.

Cat. No.
683–702. Overbeck, Count Gustav v. Hong Kong, China.
128. Pfeil, C. A. Charlottenburg, Prussia. Porcelain.
362. Bastos—Ferreiros Pintos, Portugal. Porcelain and stone china-ware.
156. Rädler and Pilz. Vienna. For enamel paintings on porcelain.
263. Tschinkel, Anton. Eichwald, Bohemia.
132. Uechtritz and Faist. Schramberg, Wurtemberg. Clock faces, &c.
231. Town of Kioto, Quarter Avata and Godjiosaka, Japan. Faïence and porcelain.
231. Town of Nagasaki, Japan. Porcelain.
57. Vion, D., and Baury. Paris. Porcelain and biscuit ware.
8. Devers, Giuseppe, Cav. Turin, Italy. Painted and enamelled plates.
— Hsii. Hankow, China. Porcelain.

DIPLOMA of HONOURABLE MENTION for PORCELAIN and STONE CHINA-WARE.

131. Department of Ishikawa, Japan.
41. Detemmermann. Paris. Porcelain flowers.
130. Dressel, Kister & Co. Bavaria. Porcelain figures.
256. Fabrik, Gräfliche Stadnicki'sche. Frain, Moravia. Stone china and Wedgwood-ware.
149. Fabrik Stein-gut. Damm, Aschaffenberg, Bavaria. Porcelain and stone china-ware.
122. Fabrik Waechtersbacher. Schlierbach, Hesse Nassau. Stone china-ware.
121. Heckmann, C., and Rappsilber. Prussia. Porcelain.
125. Macheleidt, Triebner, & Co. Schwarzburg-Rudolstadt. Porcelain figures.
233. Riedl, David, Freiherr von. Bohemia. Dallwitz, near Carlsbad. Porcelain.
231. Mansuké. Guifou, Japan. Porcelain.
58. Woodcock, F. Paris. Porcelain flowers.
19. Andreas Titoff, Rostow. Government Jaroslow, Russia. Enamel paintings.

MEDAL FOR PROGRESS.

Pottery.

490. Rörstrand, Company. Stockholm. For maiolica stoves, &c.
28. Bonafede, Leopold. St. Petersburg. Chamber stoves.
31. Boulenger, H. *Choisy-le-Roi, France. Maiolica.*
152. Brausewetter, Victor. *Wagram, Lower Austria. Terra-cotta.*
37. Collinot, E. Paris. Artistic faïence.
231. Department of Aidtsi, Japan.
331. Department of Kagosima, Japan.
357. Doulton and Watts. London. *Stoneware for chemical works.*
166. Erndt Bernhard. Vienna. Maiolica stoves.
104. Farina and Company. Ravenna, Italy. Maiolica.
144. Ehrentscher, Fr. Ch. Zwickau, Saxony. Large chemical vessels.
214. Geith, J. K. Coburg. Gas retorts and fire-clay.
172. Imperial Gas Company. Vienna. Fire-clay gas-retorts.
318. Dor, Nicholas Joseph. Belgium. Retorts for reducing zinc on a new principle.
122. Staats Eisenbahn Gesellschaft. Hungary. Fire-bricks and pottery.
— Nolla, Miguel, & Sons. Valencia, Spain. Encaustic tiles.
— Severati, Filippo. Rome. Painting on faïence.

Cat. No.

264. Verein Österreichischer Aussig & Kralup. For chemical and metallurgical products. Bohemia. Earthenware vessels.
213. Vygen, H. J., & Co. Prussian Rhine Provinces. Gas-retorts, &c.
346. Minton, Hollins, & Co. Stoke-upon-Trent. Encaustic and maiolica tiles.
322. Societé anonyme des terres plastiques et produits, refractaires d'Ardenne. Belgium. Fire-clay goods, gas-retorts.
192. Alois Klammerth, Znaim, Moravia. Maiolica and domestic pottery.
322. Societé de produits refractaires de S. Ghislain. Gas retorts and fireproof wares.
196. Fabrik, Thonwaaren F. der Magdeburger Bau und Credit Bank. Province of Saxony, Prussia. Cooking stoves and fireproof tiles.
186. Christian Seidel. Dresden. Chamber stoves.
250. Franz Stowak. Znaim, Moravia. Maiolica.
180. Actiengesellschaft Laubaner Architektur, Thonwaaren und Kunstziegel Fabriken. Paris. Bricks and enamelled tiles.

MEDAL FOR MERIT.

Pottery.

— Achmed d'Assiut. Egypt. Pipe-bowls and ornamental pottery.
193. Actiengesellschaft für Ofenfabrikanten and Zimmerofen. Berlin. Stoves, &c.
93. Antonibon, Pasquale, and Son. Vincenza and Nove, Italy. Maiolica.
156. Breitenfelder and Haberditz. Vienna. Plates and dishes.
123. Castellani Torquato. Rome. Maiolica.
366. Crystal Palace Bazaar. Oporto, Portugal. Small costume figures.
315. Doulton and Company. London. Stoneware and crucibles.
164. Dubsky, Eduard Edler von Wittenau. Bohemia. Stoves.
— Escher-St. Andrä. Austria. Drain-pipes.
220. Fabrik Stettiner Chamotte-waaren. Stettin. Fire-clay goods, retorts, &c.
160. Fabrik, Stettiner Ofen. Stettin. Stoves and chimney pieces.
— Fabrica, St., in Valencia. Spain. Floor tiles.
187. Fabrik, von Meissener Ofen-u-Chamottewaaren. Saxony. Chamber stoves.
207. Fabrik, Dithmers' che Ziegel-und-Thonwaaren. Rennberg, Schleswig-Holstein. Bricks and tiles.
105. Ferniani, Conte Annibale. Ravenna, Italy. Faïence.
43. Geoffroy and Company. France (Gien). Maiolica.
220. Ibsen, P., Widow of. Copenhagen. Imitations of the antique.
187. Jelinek, Hugo, & Co. Pilsen, Bohemia. Chamber stoves.
204. Kulmiz, C. Prussia. Fire-clay goods. Gas retorts.
201. Larisch, Count Eugen. Austria. Clay goods, gas retorts.
317. Lattre de André & Co. Belgium. Clay goods, gas retorts, &c.
48. Laurin, F. Bourg la Reine, France. Maiolica.
7 & 16. Leitner, Dr. British India. Old and modern pottery.
365. Mafra, Manoel Cypriano Gomez. Portugal. Palissy ware
96. Minghetti, Angelo e figlio. Bologna. Maiolica.
200–212. Nichené. Kutaiàh, Turkey. Faïence.
322–348. Nichou. Kutaiàh, Turkey. Stoneware.
— Arsenal of Jokumski, Japan. Building material.
386. Bessell, Adolph. Dresden. Crucibles.
32. Bousquet, L., & Co. Lyons. Gas retorts.
515. Claus, Christian. Geneva. Crucibles, muffles, &c.
— Cacurnay, P. Barcelona. Gas retorts, muffles, &c.

Cat. No.

517. Fabrik Ziegler'sche Thonwaaren-in-Schaffhausen. Switzerland. Pottery and drain-pipes.
8. Gas Company of Paris. Gas retorts.
362 & 422–423. Government of Broussa. Turkey, in Asia. Pottery.
181. Greppiner Werke. Greppin in Prussia. Bricks and terra-cotta.
179. Hardtmuth, L. & C. Budweis, Bohemia. Bricks and stoneware.
8. Heukelom, H. C. van, & Co. Utrecht. Bricks.
94–95. Houssein. Turkey. Pottery.
157. Kaufmann, Joseph. Bavaria. Crucibles.
204. Lederer and Nessényi. Vienna. Water-pipes.
511. Maag, H. Schaffhausen, Switzerland. Plumbago crucibles.
126. Mehlem, Franz Anton. Bonn, Prussia. Stoneware, &c.
115. Miliani, Cesare. Italy. Stoneware.
142. Nordmann, Gebrüder. Altenburg, Germany. Chemists' vessels.
217. Oettingen-Wallerstein, Carl-Furst v. Austria. Clay water-pipes.
101. Pagliacetti, Raffaello. Florence. Terro-cotta busts.
82. Paneris, Nicolo. Savona, Italy. Cooking vessels.
29. Pfeifer, Joseph. Oraviczà, Hungary. Crockery for domestic and technical purposes.
— Pickmann & Co. Seville, Spain. Faïence and crockery.
99. Rondani, Tolomeo. Parma, Italy. Crockery and terra-cotta.
174. Saeltzer, August. Saxe-Weimar. Drinking vessels in Grès de Flandres style.
298 to 306. Salih. Constantinople. Pipe-bowls.
231. Sampei. Avadgi, Japan. Faïence.
239. Schäffner, Victor. Floridsdorf, near Vienna. Water-pipes and large clay vessels.
133. Schierholtz, Christian Gottfreid, and Son. Saxe-Weimar. Apothecaries' ware.
241. Schleiss, Franz. Gmunden. Enamelled and glazed crockery.
1. Schmidl, Maximilian Dr. Austria. Consul in Morocco. Collection of Moorish pottery.
194. Schröder, R. F. Potsdam, near Berlin. Stoves.
246. Schütz, Gebrüder. Moravia. Glazed stoneware.
— Slevat, Bens. Spain. Mosaic and encaustic tiles.
321. Smal-Smal & Co. Namur, Belgium. Fire-clay goods.
253. Somerschuh, W. F. Prague. Chamber stoves.
120. Spinaci, Giovanni. Umbria, Italy. Gubbio ware.
221. Steigerwald, F., Nephew of. Munich. Vases in Pompeiian style.
351. Taylor, Robert Minton. Fenton, near Stoke-on-Trent. Encaustic tiles.
27. Tsybulsky, Casimir. Russia. House pottery.
202. Villeroy and Boch. Saxony. Stoves, wall tiles, &c.
231. Kioto, the town of, Quarter of Awata. Japan. Faïence.
796. Wedgewood, Josiah, and Sons. Etruria.
2. Zsolnay, Wilhelm. Fünfkirchen, Hungary. Domestic pottery.
27. Aubry, J. Bellevne, near Toul, France. Maiolica.
195. Komers, A. E. Mostau, near Eger, Bohemia. Terra-cotta.
203. Lübcke & Hornemann. Haffburg, near Wismar, Mecklenburg-Schwerin. Chamber stoves.
140. Carl Weisshuhn. Wald-Olbersdorf, Austria. Tiles and bricks.
97–100. Ahmed. Kalcï-Sultanié. Earthenware.

NOTE.—The terms Chamotte and Chamotte-ware used above signify articles made of fresh fire-clay mixed with broken retorts, crucibles, fire-bricks, &c. This improves the refractory quality of the Continental fire-clay, which in that respect is much inferior to the English.

HONOURABLE MENTION DIPLOMA.

Pottery.

Cat. No.
11. Andrik, S. Tamásfalva, Hungary. Chamber stoves.
28. Barbizet, A. Paris. Style of Bernard Palissy.
369. Barlou, John. Lisbon. Faïence.
231. Department of Miné. Japan. Faïence and biscuit ware.
162. Diebl, Franz. Vienna. Chamber stoves.
183. Fabrik, Sinziger Mosaikplatten und Thonwaaren. Encaustic floor-tiles.
91. Galvani, Andrea. Pordenone, Italy. Faïence.
705 to 6. Haas, Joseph. Shanghai. Clay figures.
358. Jones, G. Stoke-on-Trent. Maiolica.
18. Kerekes, Andreas. Hungary. Chamber stoves.
— Rutto-Wullud-Mengho. Hyderhabad, India. Crockery.
— Saboo. Nussurpore, India. Crockery.
237. Samassa, Albert. Laibach, Austria. Stoves.
116. Scappini, Pietro. Italy. Imitations of Etruscan vases.
236. Schadler, Bernhard. Linz, Austria. Stoves.
197. Schmidt, Fr. W. Nürnberg. Dutch-tile stoves.
192. Schmidt, J. T. Weimar. Dutch-tile stoves.
172. Schwarz, J. v. Nürnberg. Faïence figures and vases.
218. Schwarzenberg, Johann Adolp, Prince of. Austria. Terra-cotta.
247. Scuola, Reale Superior. Dalmatia. Bricks and building materials.
53. Sergent, Th. Paris. Palissy ware.
251. Slowak, F. Ignaz. Znaim, Moravia. Crockery.
103. Societa Pessarese. Pesaro, Italy. Maiolica.
31. Sonnenberg, M. and J. Hungary and Croatia. Crockery.
54. Soupireau and Fournier. Paris. Maiolica.
89. Squercina, Giuseppe. Padua. Flower pots.
15. Stepanoff, Michael. Vassiliéve, near Moscow. Gas retorts.
— Székely, Andreas. Nagy-Kuszon, Hungary. Crockery.
130. Tajani, Giovanni. Salerno, Italy. Floor-tiles.
135. Thewaldt, J. Hesse Nassau. Stoneware chemical apparatus.
173. Thorschmidt, C. L., & Co. Dresden. Terra-cotta for garden decoration.
184. Utzchneider and Edward Jaunez. Saargemünd, Alsace. Paving tiles and encaustic tiles.
84. Airaghi and Boni. Milan. Terra-cotta.
202. Berg and Hüttenwerke in Johannesthal, Krain, Austria. Fire-brick and muffles.
209. Bergwerks, Verwaltung, freiherr, v. Waitz'sche in Hirschberg, Near Gross-Almerode, Hesse Nassau. Fire-brick and clay wares.
139. Bihl, Ernst & Co. Waiblingen near Stuttgart. Roof tiles and drain pipes.
134. Bongiovanni, Vaccaro Salvatore. Caltagirone, Catania, Italy. Costume figures in terra-cotta.
88. Boni, Andrea. Milan. Terra-cotta.
— Cubil and Yarroo. British India. Clay manufacturers.
80. Chinaglia, Marcello. Turin. Terra-cotta.
15. Committee of the North-west Provinces of India. Various works.
10. Compaddy of Goodiana. North Arcot. Pottery.
— Czegel, C. Hungary. Fire-clay goods.
— Czermak, Joseph. Vienna. Chamber stoves.
203. Eberard, F. A. M., & Sons. Brazil. Pottery and crucibles.

Cat. No.

235. Eisengieserei, Fürstliche Salm'sche. Blansko, Austria. Fire-clay goods.
167. Erndt, Franz. Vienna. Pottery.
169. Fötinger, Johann. Gmunden, Austria. Pottery.
171. Gesellschaft, Eisenindustrie Steirische. Styria, Austria. Fire-clay goods.
334. Gesellschaft Salzburger — Torfmoor — Biermoos. Turf-burned bricks, &c.
208. Gewerkschaft; Steinberger in Gross-Almerode. Hesse Nassau, Prussia. Fire-clay works, &c.
174. Gessner, Pohl & Co. Müglitz, Moravia. Turf-burned fire-clay goods.
10. Goedewaagen, P. Gouda, Holland. Tobacco pipes.
2–10. Government of Edirna. Turkey. Pipe bowls.
240–246. Government of Hidjas. Turkey. Water bottles, Alcarazas.
154. Gundlach, Wilh and Son. Hesse Nassau. Crucibles.
92–111. Hamdji Effendi. Turkey, Constantinople. Pipe bowls.
319. Hynam, John. England. Plumbago crucibles.
140. Jahn, M. Bitterfeld, Saxony. Water pipes.
— Joomo, Son of Oosman. Kurachee, British India. Pottery.
188. Jordan, Franz. Austria. Earthenware.
— Keppler. Marburg, Hesse Nassau. Cooking utensils.
143. Graf, C. Deggendorf, Bavaria. Chemists' vessels.
166. Koedgen, Gebrüder. Coblentz. Chemists' vessels.
198. Kugler, Ignaz. Klosterneuberg, Lower Austria. Clay muffles.
20. Ladányi, Michael. Hungary. Pottery goods.
21. Ladányi, Stefan. Hungary. Pottery goods.
167. Lewetzow, Von. Schleswig Holstein. Garden pottery.
22. Lukács Desider. Hungary. Crockery.
1–90. Mehmed Effendi. Constantinople. Pipe bowls.
210. Moest, Carl. Znaim, Moravia. Crockery.
599–612. Morpurgo, Count von Nilma. Tunis. Floor tiles and pottery.
129. Mosca, Brothers. Naples. Crockery ware.
286–292. Mustapha. Rustchuk, Turkey. Crockery.
47. Mustapha. Trebizond. Turkey. Pipe bowls.
137. Naumann, Franz. Germany. Terra-cotta.
197. Krauz, Vincenz. Bohemia. Cooking utensils.
165. Lampé, W., & Co. Mecklenburg-Schwerin. Household crockery.
133. Lorenzo Giacomo di Portale. Italy. Costumé figures in clay.
203. Lübcke and Hornemann. Mecklenburg-Schwerin. Chamber stoves.
190. Lunz, Theodor. Nürnberg. Stoves in maiolica.
208. Mayer, Carl. Moravia. Chamber stoves.
19 & 21. Peerano, Son of Jomoo. British India. Crockery.
222. Planckh, Victor. Krauska, Moravia. Faïence.
224. Poduschka, Ignaz. Austria. Crockery, stoneware, &c.
6. Ravenstein, Gebrüder. Utrecht. Wall tiles.
109. Riccerri, Domenico e Figli. Florence. Crockery.
320. Rodin, August and Joseph van. Rasbourg, Belgium. Busts in terra-cotta.
234. Rollepatz, Franz. Moravia. Stoves.
98. Rubiani, Carlo. Modena. Enamelled pottery.
2. Vernoni. Egypt. Pottery dishes.
226. Verwaltung-Ziegelei-Troppau. Austria. Brick and tiles for floors.
229. Wendrich, V. Copenhagen. Imitation of antique pottery.
146. Zeller, Constantin. Alsace, Germany. Drain pipes.
80–85. Ahmed. Inseln, Turkey. Earthern vessels.

Cat. No.
175. Josef Ginzelmeyer. Vienna. Chamber stoves.
176. Görg & Kupke. Biala, Galician Austria. Chamber stoves.
143. C. Graf. Deggendorf, on the Danube. Tiles.
159. Heinrich Wick. Marburg, Hesse-Nassau. Cooking utensils.
2–10. Ali. Adrianople, Turkey. Pipes and cigar tubes.
— Ziegler & Co. Tabris, Persia. Tiles.
148. Actiengesellschaft. Prague. Bohemia. Building materials.
429. Bakir. Bagdad, Turkey. Earthenware.
73. Commissione dell'esposizione di Lecce. Italy. Pottery and stoneware.
90. Andrea Fontebasso. Treviso, Italy. Maiolica.
102. Resignani, E., Comp. Reggio, Italy. Pottery.

MEDAL FOR GOOD TASTE.

9. Dr. Hunter, School of Art. Madras. Work in terra-cotta.
13. Society for Art and Industry. Monaco. Painted terra-cotta.
— Po-hing. China. Decorated porcelain.
— Quong-hing. China. Decorated porcelain.
— Yut-ching. China. Porcelain vases.

APPENDIX E.

It is thought by the reporter that a complete list of the artists and artizans who were thought worthy of especial reward will be both useful and interesting, for the following reasons:—First, manufacturers may wish to know where such talents are located, and secondly connoisseurs and others may feel interested in learning the names of those whose works give a charm to the ceramic manufactures of the day. Only those belonging to our British firms have been printed in the body of the report, and they appear again in this list as a more convenient index for reference to them. Also those independent workers who obtained medals of progress, merit, or good taste, and diplomas of honourable mention as decorators of porcelain, &c.

1ST. INDEPENDENT WORKERS.

Kosch, Franz. Vienna. Decorator of porcelain. *Medal for progress.*
Severati, Filippo. Rome. Faïence painter. *Medal for progress.*
Castellani, Torquato. Rome. Faïence painter. *Medal for merit.*
Denk, Madame. Vienna. Porcelain decorator. *Medal for merit.*
Harrass, Adolph, of Schwarzenburg Sonderhausen. Porcelain decorator. Medal for merit.
Thallmaier, Fr. X. Munich. Porcelain decorator. Medal for merit.
Zasch, Joseph & Co., Portrait Painters on Porcelain. Medal for merit.
Association of Artists, Yeddo, Japan. Porcelain decorators. Medal for merit.
Wilhelm, Chr. jun. Schwartzburg-Rudolstadt, Germany. Porcelain decorator. Medal for merit.
N. Hubel. Vienna. Paintings on porcelain. Medal for merit.
Anger, Carl. Aich, Austria. Photographer on porcelain. Diploma of honourable mention.
Fischer, Ignaz. Buda Pesth. Porcelain decorator. Diploma of honourable mention.

Heinz, Georg. Vienna. Porcelain decorator. Diploma of honourable mention.
Hille, Jacob. Vienna. Porcelain decorator. Diploma of honourable mention.
Jäckel, Fortunat. Vienna. Porcelain decorator. Diploma of honourable mention.
Saxinger, Georg. Vienna. Porcelain decorator. Diploma of honourable mention.
Beck, Ferdinand. Vienna. Porcelain decorator. Diploma of honourable mention.
Weybora, Eduard. Vienna. Porcelain decorator. Diploma of honourable mention.
Houry, J. Paris. Porcelain decorator. Diploma of honourable mention.
Rousseau, E. Paris. Porcelain and faïence decorator. Diploma of honourable mention.
Thierry, G. Paris. Porcelain and faïence decorator. Diploma of honourable mention.
Willert, H. Vienna. Flower painter on porcelain. Diploma of honourable mention.
Ens and Greiner. Saxe Meningen, Germany. Porcelain decorators. Diploma of honourable mention.
Haag, Carl. Schwarzburg-Rudolstadt. Porcelain painter. Diploma of honourable mention.
Alois Gesswald. Vienna. Porcelain painter. Diploma of honourable mention.

Artists and Artizans' Medal.

For Excellence of Workmanship.

Austrian Manufactories.

Messrs. Haaz and Czizek, of Schlaggenwald, Bohemia.
Herr Adolf. Modeller.
Herr Schmied. Chief painter.
Herr Stark. Chief thrower and turner.

Messrs. Fischer and Mieg. Pirkenhammer. Bohemia.
C. Bauer. Historical painter.
Franz Bretsch. Designer.
A. Carrier. Chief decorator and animal painter.
Joseph Korb. Foreman of the works.
Joseph Preissler. Inspector of decorations.

Herr Alois Klammerth. Znaim, Moravia.
Anton Clam. Decorator.
Vinzenz Dworzath. Chief thrower and turner.

The Brick and Building Material Manufacturing Company of Vienna.
Herr Wenzel Rambauseck. Manager of the brick department.
Herr Carl Richter. Chief modeller. Terra-cotta department.

Moritz Fischer von Farkashazi. Herend, in Hungary.
Herr Rudolf Fischer. Chief painter.
Herr Carl Vogl. Modeller.

Messrs. L. and C. Hardtmuth. Budweis. Bohemia.
Herr Alexander Heller. Foreman.
Herr Franz Slowak, of Znaim, Moravia.
Herr Edmund Steckmeier. Maiolica painter.

PRUSSIAN MANUFACTORIES.

The Royal Porcelain Factory. Berlin.
Herr Looschen. Chief painter.
Herr Julius Mantel. Master modeller.

Messrs. Ernst March and Söhne. Charlottenburg.
Herr Busch. Foreman.
Herr Kurth. Modeller.
Herr Wandt. Chief modeller.

Messrs. C. Tielsch & Co. Altwasser in Silesia.
Herr Heinrich Eisenecker. Technical director.
Herr Robert Simon. Chief painter.
Herr Sommer. Modeller.

Messrs. Villeroy, Boch, Kurcher, & Co. Metlach.
Herr Josef Jacobs, Inventor of their pyrometer. Luxemburg.
Herr Josef Keffer. Architectural designer.
Herr August Kunz. Designer. Foreman modeller.
Herr N. Spengler. Machine master.
Herr Chr. Warth, inventor of the process of chromo-lithography on porcelain, &c. used by this firm.
Herr Johann Zens. Foreman of decorative work.
Herr Anton Weissmüller. Chief modeller.

SAXONY MANUFACTORIES.

Royal Porcelain Works. Meissen.
Herr Leuteritz. Manager.
Herr Müller. Foreman painter.

Messrs. Villeroy and Boch. Dresden.
Herr A. Apitz. Foreman of the clay department.
Herr Jacobs. Modeller.
Herr Zimmer. Foreman of painters.
Herr Anton Pesckner. Chemist.
Herr Nicolaus Schweitzer. Chief modeller.

DANISH MANUFACTORIES.

No names of workmen were sent to the jury, although it was evident from the excellence of the works exhibited that many deserved the reward.

SWEDISH MANUFACTORIES.

Actiengesellschaft Rörstrand. Stockholm.
Herr Erneste Jacobson. Designer.

The "Fayencefabrik Gustafsberg." Stockholm.
Herr Magnus Iseus. Designer.

RUSSIAN MANUFACTORIES.

No names of co-operators were sent to the jury.

JAPANESE MANUFACTORIES.

Massoukitshi. Porcelain painter. Yeddo.

MONACO MANUFACTORY.

The Fine Art and Industrial Company in Monaco.
Messrs. Fischer and Gemalin. Modellers and decorators.

ITALIAN MANUFACTORIES.

The Marquis Ginori. Doccia near Florence.
S. Leopold Ninkeri. Director of the works.
S. Lorenzo Zecheroni. Painter on porcelain.
Cav. Giuseppe Benassai. Director of the painters.
S. Tito Benelli. Formatore.
S. Giusti Enca. Chemist.
S. Angelo Ferniani. Director.
S. Spiega Erneste. Maiolica painter.
S. Jefte Torelli. Modeller.

Signor Andrea Boni. Milan.
Henry Braga. Modeller.

The Count Annibale Ferniani. Faenza.
S. Joseph Calgi. Painter.
S. Achilles Contavalli. Modeller.
S. Sega Savino. Formatore.

FRENCH MANUFACTORIES.

M. Theodor Deck. Paris.
M. Anker. Figure and historical painter.
M. Benner. Animal painter.
Mädame Escallier. Flower painter.
M. Gluck. Landscape painter.
M. Lachenal. Designer of ornament.
M. Legrain. Genre painter.
M. Midoux. Foreman of the ateliers.
M. Ranvier. Painter of mythological subjects.
M. Reiber. Architectural designer.
M. Zerling. Foreman of the painters.

M. E. Collinot. Paris.
M. Anatole. Foreman.
M. Etienne Onsime. Foreman of designers.
M. Paulin van Rieman. Chief painter.

Messrs. Geoffroy & Co. Gien, France.
M. A. J. Blu. Chief decorator.
M. Lahaye. Chief modeller.
M. Longuais. Director of the the works.

Messrs. Ad. Hache and Pepin Lehalleur. Paris,
M. Codoit. Foreman.
M. Gaulin. Chief modeller.

BRITISH MANUFACTORIES.

Messrs. Mintons. Stoke-on-Trent.
Léon Arnoux. Director of the works.
Mr. J. Allen. Decorator.
Mr. Aaron Green. Portrait painter.
Mr. George Green. Gilder.
Mr. George Leason. Manager of the clay department.
Mr. Thomas Longmore. Modeller.
Mr. Henry Mitchell. *Landscape painter.*
Mr. Alfred Reynolds. Painter on *porcelain, &c.*
Mr. M. Solon. Artist in "pâte sur pâte."
Mr. G. Spielsberg. Flower painter.
Mr. Chas. Toft. Artist in Henri II. ware.

The Royal Worcester Porcelain Company.
- Mr. E. Bejot. Painter in the Japanese style.
- Mr. James Callowhill. Flower and animal painter.
- Mr. Thomas Callowhill. Enamel painter.
- Mr. Edward Probert Evans. Manager of the clay department.
- Mr. James Hadley. Modeller.
- Mr. J. Rainford. Gilder and painter.
- Mr. J. Rushton. Figure painter.

Messrs. W. T. Copeland and Sons. London.
- Mr. Abraham. Designer and modeller.
- Mr. Besche. Figure painter.
- Mr. Hürten. Flower painter.
- Mr. Müller. Gilder.
- Mr. Taylor. Modeller in parian.
- Mr. Weever. Fruit and animal painter.
- Mr. Jones. Modeller.

Messrs. Josiah Wedgwood & Sons. Etruria.
- M. Léssore. Chief painter.

PROFESSOR ARCHER.

GLASS.

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REPORT on the MANUFACTURES of GLASS, including ENAMELS.—(Section 3, Group IX.) — By PROFESSOR T. C. ARCHER, F.R.S.E., Director of the Museum of Science and Art, Edinburgh, President of the Royal Scottish Society of Arts.

IT was to be expected that an Exhibition held, as it were, in the very centre of the Continental glass industry, would call forth a noteworthy display of that beautiful material, and those who formed that expectation were not disappointed. No such exhibition of the art of the glass-worker has ever before been seen. Venice, Bohemia, Hungary, and Bavaria did their utmost. France and Britain, however, were in the background. France especially. England sent a little, but that little was good. Most of our great glass-makers were quite unrepresented; whatever their motives for abstension, the effect was bad. A department of our manufactures in which we could have made a good appearance seemed to have sunk into insignificance, and the visitors to the Exhibition, not having a fair opportunity of contrasting the relative merits of purity of material, and artistic colour effects, would naturally lean to the latter, in consequence of seeing such a truly magnificent display of it. Almost every article was bought, and so the taste would be widely spread to the detriment of the pure crystal glass trade, which was only represented by three or four firms.

The geographical arrangement of the Exhibition began at the western, and ended at the eastern extremity of the building, therefore our own country comes first in this disposition, as neither Brazil, nor the United States, which were nearer the extreme west, exhibited at all in this section.

BRITISH GLASS.

One half of those who exhibited were merchants and not manufacturers, and had it not been for their public spirit our display of glass would have been painfully insignificant, whereas we could have taken, and easily maintained the first position with respect to the so-called crystal-glass. When we remember that the first International Exhibition was held in a palace of glass, which was decorated by its grand fountain of glass, and had its 100 British exhibitors of glass in all its various applications, it is difficult to account for the

apathy shown on the present occasion, only nine exhibitors of all kinds having appeared; ten are named in the catalogue, but one of them was not forthcoming.

Mr. James Green, 35, Upper Thames Street, however, was a host in himself, and his magnificent display will long be remembered by those who had the pleasure of seeing it. From the superb chandelier which was so conspicuous an object in the British department down to the plainest wine-glass in the immensely varied exhibition on the stands below, everything told of purity of material, great care in manufacture, and good taste in design. The diploma of honour would not have been ill-bestowed upon Mr. Green, and the jury did award him the medals of progress and good taste, but the singularly absurd regulation which defined qualities of merit, and then refused to admit that one person could have two of those qualities, led to the striking off the second award.

Another old and esteemed firm which has never been behindhand upon such occasions, namely, Messrs. Pellatt and Co., of the Falcon Glass Works, Blackfriars, received similar justice at the hands of the jury, only to have the award similarly curtailed. The quality of the specimens they exhibited was unsurpassed, and although they were as remarkable for good taste in design and decoration as for the fine quality of the material, and were consequently awarded the medals for "progress" and "good taste," yet they were deprived of the latter either by the Council of Presidents, or by the Bureau of Central Direction which made the final revision.

The Falcon Glass Works, established in 1735, are perhaps the oldest in Britain as regards the manufacture of "flint glass," and the extreme purity of the glass made there is due in a great measure to the use of the sand of Fontainebleau, which has been used for the last twenty years. As much as six tons of the finest, and twice as much of a second quality of glass, are made weekly, and this, and the kindred firm of Messrs. Pellatt and Wood are entitled to the merit of having revived the beautiful old style of diamond cutting and applying it to the most exquisitely delicate forms, light and thin as the best Venetian. At present the manufacture is carried on by Messrs. Pellatt and Co., and the designing, cutting, and engraving by Messrs. Pellatt and Wood.

The most noticeable pieces in their remarkable collection were the following:—A large ewer and wash-hand basin of the most brilliant "metal" and corresponding richness of

cutting. This is probably the largest piece of cut flint-glass work ever produced in England of such high quality.

There were several table services of new designs in the finest polished cutting executed in close resemblance to engraved work by means of extremely small wheels with fine edges. The designs consist of interlaced bands, and simple bands and shields of the most minute cutting with festoons of polished beads and circlets of pearls. The beads and pearls are polished as well as engraved by the wheels.

Of the regularly engraved designs there were numerous beautiful examples, and they were quite free from that too common error of glass cutters and engravers, namely, over-crowding. It is too frequently the case that the engraver forgets that there is a beauty in the material itself quite apart from the work he bestows upon it, and in his anxiety to show as much as possible of his skill he covers the surface and confuses the work. The designs of Messrs. Pellatt and Wood were simple and elegant, and their admirable execution was made apparent by the ample breadth of pure background upon which they were placed.

The infusion of Japanese art which is steadily entering into European designs was apparent in a very charming service with engraved panels in which were storks and vases with plants, and the conventional key bands and scrolls of Japan work. The adaptation of this ornamentation to so novel a material as flint glass was very skilful, and reminded the observer of some of the highest qualities of Chinese engraving on pure rock crystal. Another service in Japanese style, had, instead of rectangular panels, quatrefoil-shaped ones with minute engraved pearls on the border, and the centre being very well filled with bamboo and palm foliage, with a kingfisher perched on a stump and a stork below it. A third set, entirely differing in design, which was rather more in Chinese than in Japanese style, consisted of decanters formed upon the model of jade, or rock-crystal vases engraved in broad long panels forming bands round the upper part of the body of the decanters, and around the upper part of the glasses between each pair of panels; from lines forming their lower edges rises a key pattern forming together a small pedestal upon which rests a vase of a flattened Oriental figure. Springing from the vase is a branching plant, most artistically arranged in a light and pretty manner to run up and spread along a broad band, which separates the panels and extends above them continuously.

A very elegant service engraved with the adaptation of an old French design was remarkable for the extremely delicate work in the festoons and pendant flower vases which formed the circle of ornament around the pieces, and covered very little of the beautiful clear material. A great variety of designs on wine glasses showed how completely the requirements of fashion are met by the glass engraver, who with a delicacy of handling equal to that of the seal engraver places the most complicated armorial bearings in the most tasteful manner upon glasses of every pattern. Two most elaborately and elegantly decorated claret jugs must finish this attempt to describe the excellent designs of Messrs. Pellatt and Wood. The first was engraved with masks representing the four seasons accompanied with flowers and foliage suitable to each. The other with amorini playing; some tilting with bullrush spears at swans, others swinging in festoons of flowers. It is quite impossible by mere description to give an idea of the extreme beauty of execution in these works.

Messrs. Copeland & Sons, of 160, New Bond Street, London, received the medal of merit for engraving on glass, which their firm has carried to very great perfection. This is now considered a branch of art quite apart from the manufacture of glass itself, as many firms receive plain blown glass, and employ engravers to execute it. Mr. Green and Messrs. Copeland are notable examples of this.

One very remarkable engraver, Mr. P. Oppitz, employed by the latter firm, is a man of real genius, and fully understands the difficulties under which an engraver on glass labours. First, he has no breadth of surface, and secondly he is limited by the thickness of the article upon which he is working for his effects of light and shade, and still more of expression if he is bold enough to choose figure subjects. Mr. Oppitz in his two handled vase has grappled with every difficulty, and has mastered all; his figures are beautifully moulded and their faces are full of expression. It is a work of the highest merit, and shows all the operations of glass engraving in their most refined stages. It would be quite impossible to give all the notes made on the exhibits in the glass department of Messrs. Copeland, without becoming tedious, but could it be done it would prove that they give immense attention to this beautiful art, and are amongst the foremost in sustaining the reputation of Great Britain as the country in which glass engraving and pure crystal glass is at present carried to the highest perfection.

In the American Section of the Machinery Hall a new adaptation of an Old-world process, the erosive effects of sand, attracted crowds of visitors. This, the invention of General Tilghman, of the United States, consists simply of a vacuum box, an iron pipe of chilled iron, a steam jet, and some sand. For monograms and simple designs its operation is almost momentary, the figures or number being produced as in stencilling, but for the elaborate specimens of engravings on glass which were exhibited but not produced before one's eyes, a system of coating with collodion was adopted, the various tones being produced by a longer or shorter exposure to the "Sand Blast," to give the machine its correct name. As yet very crude, there is much in this machine to, we will not say revolutionize, but certainly cheapen artistic engraving on glass, at least as far as machinery can ever compete in artistic regions with cultured brain and skilled manual power.

In remarkable contrast to the works of the engravers and cutters on glass, are the glass pressers or moulders, a very numerous class of manufacturers in Great Britain, but only fairly represented by one firm in our department of the Vienna Exhibition, viz., that of Messrs. E. Moore & Co., of "The Tyne Flint Glass Works, South Shields," whose pressed table glass made chiefly for exportation was certainly the very best representation that could have been made of this manufacture, and gained for them the medal for merit. The extreme purity of the material; the perfect regularity of pyramidal and lozenge shaped elevations, in imitation of the old fashioned style of deep cross cutting on thick table glass, the good forms of the various articles, and their wonderful cheapness excited much astonishment, and admiration. They had no competitors in the whole exhibition, and few amongst the jury were prepared to see this cheap and hitherto somewhat dispised process carried to such a state of perfection and practical utility.

This kind of glass manufacture has in former exhibitions taken no position whatever; it may almost in its present condition be regarded as a new production. Previous to the year 1850, the manufacture of *pressed* glass was a novelty, and as a branch of the trade quite in its infancy, the variety of articles produced being small, and the shapes crude.

From that date the development of this style has been rapid. The improvement in the construction of moulds has

been constant and marked, so that every class of articles in tableware is now produced in this manner, and shapes and patterns have been much improved from the study of good models.

The English manufacture does not now enjoy the advantage it had in former years against foreign competition, because much of the raw material is now imported, which was formerly found at home, and the advantage of cheap coal is a thing of the past.

The produce in this branch of the glass trade is now very extensive, and the consequent competition has brought prices to a very low point.

These works contain five furnaces of 48 pots, capable of turning out 100,000 lbs. weight of pressed glass weekly, and in busy times employing about 500 persons.

It is to be regretted that our makers of cheap glass, glass for the million, were wholly unrepresented; had it been otherwise we should have shown that both in cheapness, and in quality we have in this country attained a position which places us before all others, a very gratifying fact, but not a very profitable one unless it is well known to the rest of the world.

Messrs. A. B. Daniell and Son, 46, Wigmore Street, London.—This firm was *hors concours* by a rule which, if strictly followed, is a good one in all great international exhibitions where only one class of merit is admitted as a title to reward. In the Vienna exhibition administration, however, there were some spasmodic efforts at doing right, counterbalanced by some very systematic arrangements for counteracting those efforts. Thus amongst many other blunders, which it is not the object of this report to point out, except so far as is due to the interests of the exhibitors in this section, although a medal for good taste was provided, it was not allowed to be given to *dealers* who were not *manufacturers*, except when the rule could be evaded. Now, if a manufacturer of objects in which good taste and other qualities are of necessity combined, receives a medal for merit, it implies every good quality. And the medal for good taste ought certainly to have been reserved for those whose good taste is quietly diffusing that quality through the masses, by selecting for sale such productions as combine both economic and æsthetical qualifications. In the British department it was impossible to avoid feeling this, when one examined the fine collections of Messrs. Daniell, and Mr. John Mortlock, for the effort they made to sustain the reputation

of their country was very great. Cynics may say, and have said, that such efforts only mean self-interest. The same may be said of Palissy, of Wedgwood, of a hundred others, but no one who knows the difficulties and the annoyances of an exhibition, and especially of the Vienna Exhibition, will ever believe that the mere feeling of self-laudation and self-advertising would have induced respectable men to leave their good and certain businesses in London, and expose themselves to the difficulties and dangers of the distant Austrian Exhibition for no worthier feeling. The Royal Commission of Great Britain, with our noble Prince at its head, appealed to the manufacturers and others to come forward and sustain the reputation of our country in one of the greatest competitions; and some saw the full force of the appeal and went forward, and England has certainly benefited in the estimation of the world thereby. Not perhaps in the estimation of those who reduce such things to the current value of the *present*, but certainly in the estimation of those who can look a little further, and who know that there is a value attached to the term prestige. The two firms alluded to did nobly; they spared no expense and they gathered together the riches of our manufacturers, and instead of leaving them to be sold at good profits in London, where such things are always in demand, they sent them to be exhibited for six months in a distant country on the mere chance of a sale. Those who did not go did not believe in a sale being probable. Perhaps the probability was not more apparent to those who did, but they went because they felt compelled by a higher consideration, and they took with them what ought to have insured them, under judicious administration, the reward for good taste. The beautiful glass exhibited by Messrs. Daniell was exclusively the manufacture of Messrs. Thomas Webb and Son, of Stourbridge, and its colour and wonderful brilliancy were universally admired. The perfectly plain specimens were the best, as they exhibited the exquisite purity and brightness of the material. There is glass-cutting and glass-engraving; in the former the Messrs. Webb excel, it is their specialty, and no better specimens were in the exhibition. I was pleased to hear the enthusiastic remarks of my co-jurors upon the lightness of our table-glass, and could not but reflect how very recently we have escaped from hideous clumsiness and ugliness. In engraved glass, which was not the strongest point of Messrs. Daniel, they had nevertheless, a remarkable novelty. It was a service of

glass engraved with Japanese decorations, which certainly was quite unique. The well-known bamboo and the storks, so familiar in Japanese art ornament, were most beautifully introduced, and worked out with great delicacy of feeling and manipulation. The collection of Messrs. Daniell was very extensive, both in porcelain and glass, and it is a satisfaction to have had this opportunity of doing justice to that good taste which made their portion of the exhibition a great attraction to foreigners and a pride to our own countrymen.

The "Aire and Calder Glass Bottle Company," of Castleford, Yorkshire.—This great company was established by Mr. Breffit the present principal in 1836, when the manufacture of glass in this country struggled for, and sustained a difficult existence under the Excise laws. Like every other branch of glass making it has thriven under the wise policy of free trade, and instead of a small kiln with a dozen, or two of men closely watched, and always suspected by the officers of the revenue department, it now has 15 furnaces which when in full work can supply from 50,000 to 70,000 bottles of various forms and sizes *daily*, and gives employment in all its branches to about a thousand hands; moreover its energetic and talented principal has power to develop all his resources of ingenuity and material, and the numerous and varied forms which constituted the display of the company in the exhibition was but a small affair compared with that which an interested observer can any day see by looking into the windows of our grocers and others who sell articles in bottles, a very large proportion of which are furnished by this firm. So important has this trade become that it has cheapened all kinds of Colonial produce requiring bottles for transport, and is the means of enabling such products to be spread over every part of the world. To rightly estimate the importanee of this manufacture, let any one who can remember the "good old times" when the revenue derived a large sum by taxing the glass trade, call to mind that a bottle of sauce, of pickles, of medicine, of every thing liquid was very dear because of the price of glass, and contrast the difficulty, and I might say almost impossibility now, of getting rid of used bottles, which are so abundant and cheap they hardly pay for cleaning. The Aire and Calder Company were foremost in this revolution, and they were deservedly recognised in this exhibition where utility, and aid to material progress were held to be chief titles to distinction.

Portuguese.

The medal for merit was awarded to one of the only two exhibitors of glass from Portugal, the Fabrica de vidros da Marinha Grande, of Leiria. This firm is one of old standing, and has the chief merit of upholding the manufacture of glass in the Peninsula. The principal productions are table glass and other hollow glass ware. Window glass was exhibited by a company called "Enterprise de la Mine" at Cabo Mondzo. The appearance of these two exhibitors at the Vienna Exhibition is noteworthy chiefly as an indication of the growing enterprise of the Portuguese.

Swiss Glass.

Only one Swiss exhibitor of glass appeared in the Exhibition, namely, the house of König and Küpfer of Berne, and this firm only exhibited as decorators, not manufacturers, of mirrors and flat glass. They excel in the decoration and gilding of glass, and in etching glass, and exhibited some beautiful examples of their work, particularly in the form of finger plates for doors, and glass in screens, for which the medal for merit was awarded.

French Glass and Enamels.

Two well deserved diplomas of honour were awarded to French exhibitors in this section. The first was to the Saint Gobain, Chauny et Cirey Company, Paris. This veteran company, which in the manufacture of plate glass is first both chronologically, and it may be said also in point of quality, did not produce those grand specimens which so astonished us in 1867, and which made the French reporters so jubilant respecting the triumph of France over other nations in this respect. The fact is, there is a reason, not very occult, why the nation holding the Exhibition should do some things better than those who are visitors upon the occasion, and the same reason also suggests that the host should exercise the utmost modesty in speaking of his own works and comparing them with those of his invited guests. These remarks apply especially to glass. It requires a large amount of enthusiasm, or public spirit, or some other quality, to pack up a couple of thousand of pounds worth of fine glass to send to an Exhibition in a distant country with the probability of having to repack it, without the home conveniences for that operation, and bring it back again, the capital expended in its production in the meantime

lying idle. With so fragile a material this will daunt the boldest, and certainly the most prudent, and as the cleverest manufacturers are those who combine skill and prudence, one can understand how difficult it is to induce such men to send their brittle wares to great distances, and exposed to great risks. Every genuine artist, or mere technical manufacturer is proud of his work and proud of showing it, but he never attains to any real eminence until he has combined with this natural sentiment a value for his production which will not permit a wanton waste of skill, or labour. Hence it was that in the whole of the stupendous exhibition of glass manufactures at Vienna there was not one single plate of glass of extraordinary dimensions. The Belgians showed one plate they called large, but it was a trifle to what we know St. Gobain can produce. This company showed good specimens of thick rolled glasses for roofs, and what we call deck-lights. Their lighthouse lenses were also as usual of very fine quality. We wish the Messrs. Chance had been there to compete with them. That firm has certainly produced finer than those exhibited, but not quite so cheap This is a quality, however, which hardly ought to be mentioned in a case where the greatest perfection means the greatest safety to human life, and as lighthouses are public works, of course no public body, having the slightest idea of the enormous importance of having the best safeguard for life, would for a moment entertain a thought upon such a qualification.

The other recipient of the diploma of honour was M. Charles Feil, whose reputation as a maker of optical glass is well known to all who use optical instruments. As the great-grandson of M. Guinaud, who is regarded as the inventor of this specialty, he has nobly sustained the reputation of the house to which he has succeeded. But that which created most astonishment in the specimens shown by M. Fiel was a series of examples of a new art. At first they were taken to be glass imitations of precious stones of a marvellous quality, but they proved to be actual gems formed by a synthetical combination of the materials constituting the natural gems. Thus he had prepared most beautiful rubies, emeralds, saphires, Oriental amethysts and Oriental topazes, which in no respect could be distinguished from the natural productions.

He uses the process of A. Ebelmann, fusing the alumina base with the various colouring oxides by means of the oxyhydrogen blow-pipe. Under its intense heat a perfect fusion takes place, and in cooling some portions of the

interior of the mass assume a crystalline character, an indeed, in some instances, beautifully formed but minute crystals are produced on the outer surface. The masses when cooled are broken open, and the crystalline portions if transparent enough are cut into gems of various sizes. It is curious to speculate upon the effect this new art will have upon the jewel trade, for it is quite impossible to discriminate between M. Feil's gems and those "of purest ray serene" obtained at such cost from India, Ceylon, and other localities. Those rare stones, the Corundum emerald, amethyst, and topaz will now be plentiful enough.

The most noteworthy of those who received the progress medal were Messrs. P. Bitterlin and Sons, for crystal and mirror glass, both plain and decorated by engraving and enamelling; the "Compagnie Génerale des Vererries de la Loire et du Rhone" for bottles which the firm makes for the wine trade in vast numbers, also for plain and coloured window-glass, and drinking glasses of pure quality and good forms; and M. Ph. Brocard for his beautiful reproductions, or copies from the antique Persian and Arabic enamelled glass. These artistic works were first exhibited by him in the small exhibition of the Cours Central held in the Paris Palais de l'Industrie in 1868; they excited much attention, and were instantly bought up by wealthy connoisseurs, and for museums. M. Brocard has not surpassed his first works, indeed, the evident effort to make them more perfect is rather a drawback. There is a point at which arabesque decoration becomes less pleasing by becoming more mathematically true in its figures. The true oriental works are never so when carefully examined, although they are usually sufficiently so to please the eye. Let any one who has the opportunity of examining the grand specimens of Persian, and arabesque glass found in the form of hanging lamps, and basins, such as are still used in celebrated mosques, and he will find that the beautiful ornament is executed with a certain amount of free-handed vigour which would have been lost if the precision of drawing instruments had been adopted. M. Brocard is entitled to much credit for seeing, and reproducing the beauties of this class of glass objects.

To M. A. Mercier, of the Boulevard Beaumarchais, Paris, for his great variety in form, and the general excellence of his glass shades for covering clocks and other *objets de luxe.* This is a large and important branch of glass manufacture in France, chiefly in the neighbourhood of Paris, and great skill is manifested in the manufacture of irregular forms, and

in insuring uniformity of thickness throughout. M. Mercier has long been known to excel in this specialty.

To Messrs. M. A. Pelletier and Sons, the equally well-known manufacturers of both "flashed" and "*pot-metal*" coloured window glass both in sheets and cylinders. Their colours are particularly fine, more especially their *ruby*, which is largely imported by our English firms for church-windows. Their blues and yellows were also very rich and clear.

The only other progress medal obtained by France in this department was that given to M. Constant Valés, of the Rue St. Martin, Paris, for imitation pearls. In this peculiar manufacture M. Valés has long been unequalled, and the reporter well remembers in the Exhibition of 1862 how perfectly deceived several of the jurors were, when real and fictitious pearls were placed in their hands by M. Valés, indeed it was almost impossible to separate them by the eye.

M. Valés employs an opalescent glass upon the quality of which much depends. This is drawn into tubes of different diameters, and from these the glass blower forms the beads, one by one, by blowing a round, or other shaped bulb at the end of the tube. Into this a small quantity of the pearl liquid is dropped and shaken about until it coats the inner surface of the bulb upon which it is dried by holding it a short time near a fire; for beads of fine quality several coatings are given of the pearl fluid. This fluid is made from the scales of the little fresh-water fish so well known to the Thames anglers as the bleak. The silvery scales are removed from the belly and put into water, after a time the pearly matter on the scales sloughs off and is separated by decanting from the osseous portions of the scales, which are rejected when they will yield no more pearl matter. This pearly matter is kept in a preservative fluid, and is of great value, being worth several pounds sterling per ounce. If a string of true oriental pearls be taken in the hand it will be seen that however beautifully spherical they may appear to be, very few of them are truly so, the others having defects of shape more, or less noticeable. M. Valés' artists imitate these so perfectly that the deception is rendered complete as far as the eye is concerned, but the weight would lead to detection if not altered, which is done by injecting melted wax into the pearls after they have received their coatings of the pearl fluid. The wax answers a twofold purpose, for besides bringing them up to the weight of the true pearls, it also gives them that waxy softness of colour which characterises the best oriental pearls. A string of artificial pearls a foot long can be

produced for a shilling, but by using all the appliances of his art in their greatest perfection M. Valés can bring a string of the same length up to the value of ten pounds.

The medals for merit were awarded as follows. They are taken alphabetically. To M. Alexandre, Junr., Faubourg St. Antoine, Paris, for mirrors in the Venetian style, that is, with cut and bevelled edges. It was almost slander to call the large mirror shown by M. Alexandre, Venetian, for it was so bad in taste as compared with all ancient and modern Venetian mirrors that but for size and certain technical points of cleverness shown in its construction it was not entitled to notice.

To Messrs. Appert Brothers, 66, Rue Notre Dame de Nazareth, Paris, whose exhibits were very various, and all excellent of their kind. There were enamel glasses of every colour in sticks and other forms. Tubes for scientific instruments, as thermometers, barometers, &c., chemical glass of all kinds, besides every variety of strass or glass for the imitation of precious stones. Few glass works undertake such a wide scope of small, but important manufactures. But in all of them they show great excellence of workmanship.

M. T. Bapterosses, of Briare (Loiret), Rue de Grand Chantier, No. 7, received the reward for a very remarkable imitation of pearl buttons in glass. Sown, as they were, on cards, in the same manner as pearl buttons, it would be difficult, by the eye, to tell the true from the artificial. They were a real novelty, and excited much attention.

To M. Businger, of Rue Magnan, Paris, for a novelty in bead making. The beads were large, after the Venetian style, lately so much in fashion, from half an inch in diameter to two thirds. They were gilded inside, probably after the manner of the silvered glass from Austria, but the process was not made known. Some of them were very beautiful, and they are certain to be in great favour when known.

Messrs. J. Dopter and Co. received the medal for a process of transferring lithographed designs from lithographs to glass, a sort of etching process, which may after time be of some value in decorating glass surfaces.

It was also awarded to Messrs. Gugnon and Sons, of Paris, for mirrors and decorated glasses, some of them engraved by an ingenious machine, invented by them; and to the well-known firm of Messrs. P. C. Hugedé, of Paris, for their works, which can only be described as glass miscellanies, consisting of letters for shop-windows, &c., ornaments of all kinds for a similar purpose, heraldic ornaments,

medallions, mirrors, household glass of all kinds, enamelled plates for useful purposes, and also for decoration, &c. Indeed they seem to try with laudable zeal and unquestionable skill to supply everybody's wants. Useful as are their very meritorious works they differ widely in character from those of the next in order, Mr. Alfred Pottier, 67, Rue Montorgueil, Paris, whose enamels on copper were hardly allowed a day's exhibition before they were purchased. Some in the style of Henri II. were especially good, others decorated in more modern styles were also excellent, and all were immediately sold. This is the best testimony which can be offered to the 40 to 50 works exposed by Mr. Pottier. Two thirds were purchased for museums.

The imitation gems of Messrs. Regat and Sons, of 53, Rue Turbigo, Paris, were also awarded a medal of merit. They were very fine, and quite entitled to the award, but we missed M. Bourguinon, who in former exhibitions has always taken the lead in this specialty.

Italian Glass.

Italy held a very enviable position in respect to her glass manufactures. The old glories of Murano appeared in the wonderful revival effected by the indefatigable genius of Dr. Salviati, whose court filled with Venetian glass was one of the greatest attractions of the exhibition. Dr. Salviati stops at nothing; he has studied with delight, with good taste, and a warm enthusiasm all that has been spared to us of those wonderful works in glass of the ancient Egyptians, Phœnicians, Greeks, and Romans, especially the last, who carried the art to a perfection truly marvellous. Let any one examine that unrivalled collection for which the nation is indebted to the cultivated taste, enterprise, and generosity of Mr. Slade, now in the British Museum, and he will see such artistic management of this difficult material amongst those fragments of old Roman glass in the millifiori, reticella, calcedony, and other cunning devices to imitate the most beautiful of natural stones that he is almost led to feel that the artist has surpassed nature. Those old workers who produced these relics Dr. Salviati acknowledges as his masters, and year by year he makes nearer and nearer approaches to their admitted perfection. It is one of the most agreeable retrospects of exhibition life to see in the past the successive stages of improvement which he has effected, and to mark how very closely in some varieties he has approached his exemplars. It is gratifying, too, to those

who, like the reporter, have watched with interest this progress for the last 15 years, to see that the earnest spirit which forsook the noble, and lucrative profession of advocate for the patriotic hope of reviving one of the faded glories of his country, is now at last beginning to meet with its reward, a reward which would certainly have been still far distant, but for the liberality and cultivated tastes of two of our fellow countrymen, Mr. Layard and Sir Wm. Drake, whose admiration for the efforts of Dr. Salviati led them to aid him by all the means in their power, joining in all the risks of the manufacture, and using all their influence to make its excellences known. Judging from the enthusiastic language always used by Dr. Salviati in speaking of these gentlemen, he clearly feels that without them his task would have been all but hopeless. The success of Dr. Salviati has not been confined to himself, it has been shared in by several other glass workers in Venice and Murano, and although the former population of 25,000 on the latter island is now only represented by about 3,000, yet there are evident signs of improvement, and it is not impossible that ere very long its furnaces may again be in full glow, and the inborn genius of its inhabitants may again send their fanciful creations to every part of the world.

Venetian glass arranges itself under several distinct varieties.

1st. The blown glass for various purposes, such as bottles, drinking-glasses, vases, and other decorative objects.

2nd. Mirrors and chandeliers.

3rd. Beads and bugles.

4th. Mosaics.

And under these heads all the Venetian exhibitors will be arranged, as well as the Works of Salviati, which comprise them all.

In the blown glass of Venice there is one quality which is only found to a limited extent in any other, that is, a creative fancy. Take the Bohemian works which are next in excellence and it will be seen that a conventional fashion runs through them, and often produces a forgetfulness of the material in the anxiety for surface decoration. In England the idea of utility is uppermost, or if ornament is used it is that of the engraver, which is too costly for so fragile a material. The glass blower of Venice like a child blowing bubbles throws them off with ease and rapidity, producing with every touch of his fingers new forms of beauty which gladden his own eyes as much as the ever differing rainbow hues of the child's soap-bubble. In everything appertaining

to the blown, pinched, and moulded glass of the Venetian artist there is an exuberance of fancy, and he conjures up forms always new and always graceful and beautiful. His application of colours too is guided by the same genius, every touch tells; now he hangs on the sides of an exquisitely formed vase rings of his beautiful aqua-marine blue, or he runs a touch of it around the margin of the vase, in either case his touch is magic, and the tiny addition becomes beautiful. He imitates the beauty of coral by flashing his ruby transparent glass over his opaque lattimo, and he throws a film of his avanturine over the surface of other glasses with a skill entirely his own. But the greatest triumph of all has been in the close imitation of the beautiful variety of ancient Roman glass called calcedony. In 1862 some specimens of this were exhibited by Lorenzo Radi, who has the immense credit of having communicated his tastes and his enthusiasm to Dr. Salviati. It was considered a great success, nothing like it had been done in modern times, but it was not pleasing, it had the appearance of having been blown out of the slag of an iron furnace, indeed every one conversant with that material would have felt that he had seen more beautiful variations of colour in it. But though no one who had carefully studied the exquisite softness, and perfect blending of colour in the true antique specimens could have felt satisfied with it, yet it was a step gained, and it is a satisfaction to know that the visitors to that exhibition appreciated it and purchased every specimen. This calcedony glass has some remarkable peculiarities; at first sight a very perfect specimen has all the beautiful appearance of a clouded calcedony approaching to the opaque character of a softly waved agate. No one unacquainted with it suspects it to be more than slightly translucent, but when held so that the light is transmitted, it is seen to be of a beautiful ruby colour and perfectly transparent. Some of the Venetian artists of the middle ages produced very fine calcedony glass in small quantities, every piece was considered a *tour de force*, but few of them remain. We no longer need deplore this, for there were some eight, or ten specimens in Dr. Salviati's collection which surpassed any of the mediæval works and very nearly approached those of the old Roman workers. Good ones, but by no means equal in quality, were exhibited by Lorenzo Radi, who as a single-handed worker deserves great credit. It is easy to say that one specimen of this curious calcedony glass is better than another, but no written description can convey an idea of the difficulties of producing it. Most people have seen how the marbling upon the leaves

of books is produced, this process may also be shown in some of our confectionery manufactures. The metal slags before alluded to, give a kind of veining or streaking naturally, but none of them represent the soft variations of colour in the truest style of calcedony glass, and that is produced when the material is at an intense red heat and when the artist has only his own consummate skill to guide him.

And here it may be remarked that there is this consideration always to be given to glass manufacturers, that they are produced under vastly different circumstances to ceramic manufactures, in which the cold soft clay is easily thrown on the wheel, or turned on the lathe; but the worker in glass has to deal with a material in a state in which he not only cannot handle it in any way, but whatever he has to do with it must be done very rapidly, for every second decreases its plastic condition. In blown glass Dr. Salviati exhibited a very great variety of ornamental and useful objects, amongst which were a set of wine glasses, vases, tazzias, &c. of colourless glass from models in the Murano Museum. These were marvels of thinness and lightness, and in every respect equalled, if not surpassed, those antique prototypes so long treasured in that most admirable museum, to become again useful examples for the practical men who study there. Much also of the beautiful opalescent glasses of various kinds decorated with the vigorous and effective flowers of the Venetian style, filigrana, riticella, millifiori, &c. all beautiful and true in the nationality of their characteristics. In mirrors and chandeliers the display of Dr. Salviati's Company was most striking; one grand chandelier large enough for the Imperial Opera House was the most gorgeous display of crystal and coloured glass ever before seen. The mirrors of beautiful Venetian cut plate bordered with frames of elegant foliage in pinched glass were fit for the boudoirs of queens, and yet the prices did not forbid a far more extensive use of such charming objects. Although makers of some varieties of glass beads, the Salviati Company did not exhibit any in the Vienna Exhibition, but in their most notable specialty, mosaics, they had some magnificent specimens. One of the finest, a reredos pictured with the subject of the Last Supper, was especially admired. It was purchased for the Edinburgh Museum of Science and Art, as was also a copy from an old, probably the oldest, mosaic known, said to be the head of a saint, work of the ninth century. The mosaics of Dr. Salviati are now becoming well known in this country, and we may thank him, that this most beautiful and durable style of decoration has been made so practical, that we may look forward before long to its extensive use in our country.

When contrasted with the costliness and ponderous weight of the Roman and Russian method of producing mosaic work, that of Dr. Salviati is as one to twenty. The grand picture of Minerva in glass mosaics by his firm at the entrance to the Italian Fine Arts Court illustrated the gigantic dimensions to which they can go. A mosaic of such a size by the older method of the Vatican and St. Petersburg would weigh at least twenty tons, and would render special structural consideration necessary in any building on which it had to be placed, whilst it did not weigh probably more than two tons, and was without anxiety trusted on the walls of a temporary building. Some very fine designs on a large scale in the Salviati court had been prepared for the exterior decoration of a mansion in Berlin, a use for which they are peculiarly well fitted, as no exposure to weather affects them, and they are so easily secured to the walls.

A medal of merit was awarded to Sig. Isacco Bassano, of Murano, for mosaic and other Venetian glass works, including chandeliers, mirrors, bead-work, and other interesting objects all in very good taste.

Also to Lorenzo Radi to whom reference has already been made. Radi is a true artist and his work shows it, but he has of necessity to supply a variety of merely useful articles. Yet his production of smalti or enamel glasses for mosaics is very important, and so also is his manufacture of artificial gems for decorative purposes. He showed specimens of every variety of his work, and amongst them some clever pieces of millefiori. The same reward was given to each of the two Venetian firms, Ferro e. C. Toso, and Gregorio Toso, both of which had good selections of blown glass, also chandeliers and table candelabra of useful and ornamental character. The Cavaliero Luigi Romoli of Florence exhibited a mirror the decoration of which was of a novel kind, at least the process used was new. Those who have seen many antique Italian mirrors will have noticed some with borders of flowers and fruit painted on the back, that is, between the silvering and the glass; in all such cases the colours are very bad though usually the drawing is excellent. The reason for the dinginess of the colours is that they are affected by the mercury. In order to obviate this Cavaliero Romoli first silvers the glass and then drawing the design for the border with a needle-point afterwards removes the amalgam, and leaves the glass clear for the coloured border, which then retains its brilliancy.

The "Sociétá e Fabbriche Unite" of Venice received the Medal for Merit for smalti, canne, and other materials for use by the glass workers; so also did Luigi Olivieri of

Venice for a large and very varied assortment of those pretty ornamental beads, small mosaic brooches, studs, bracelets, and other personal ornaments for ladies' use. Many of them in imitation of the pietra-dura mosaics of Florence were very clever, and very cheap.

In order to understand the value of the extraordinary improvements Dr. Salviati has introduced into the manufacture of mosaics it is first necessary to understand the processes carried on before, as illustrated in the grand workshops of Rome and St. Petersburg. The reporter visited the latter in 1866 and thus described it:—The atelier consists of one large hall, about 50 feet by 30 feet, with a small gallery on brackets running round it, in which are cases of pigeon-holes for storing the *smalts* or coloured glass of which the tesseræ are made; these are arranged in the order of their colours and shades, which are said to number more than 12,000. The preparation of large pictures is carried on upon the floor of this hall, and the smalts are close at hand in the gallery mentioned. Besides this, there are other rooms on the ground floor for preparing the wooden frames, mixing stucco, and other operations; and above, apartments in which small mosaics are made, for tables &c., and for producing the very small tesseræ used in such works.

The first operation in preparing to copy a large picture in mosaic is to draw it on paper, or canvas in outline; then it is divided by lines into squares the size of the tesseræ, and these are coloured in with water-colours. A very strong wooden frame is then prepared; those I saw in use were of balks five inches in thickness, and about six or eight inches in depth, well clamped with iron at the angles. This frame is laid on a smooth stone table and is filled with mixed plaster of Paris, which is then left to harden and dry, after which it is turned over and the surface which was next the smooth table is found to be nearly perfect, and is rendered quite so by scraping and other operations. Upon this an outline of the picture is then drawn, and lines ruled at right angles so as to form squares corresponding with those on the cartoon, and the artist proceeds to set the tesseræ. In order to do this he begins to cut out the stucco within the outlines of the drawing one square at a time, sufficiently deep to take a quantity of mastic, made of powdered marble and oil, into which he presses the tesseræ, keeping the upper surface perfectly level; in this way he works through the whole picture, which is then turned over and laid with its face to the stone table. All the stucco is then carefully removed

from the back until the rough under surfaces of tesseræ are exposed. Roman or Portland cement is then run in so as to form a solid back to the picture, which after being cleaned is ready for removal to its destination.

The smalts or glass enamels are manufactured at the Imperial Porcelain and Glass Works, and are supplied to the Mosaic Factory from time to time as wanted. They are in round flat cakes four or five inches in diameter, and three-quarters of an inch in thickness. A small apparatus formed of six cutting wheels worked by a lathe, the wheels of malleable iron, covered with tin and coated with emery, set at equal distances on an axle, slits the cakes into strips of equal width, and these are then cut transversely or diagonally, as the artist requires, with great ease by means of a file and chisel. Smaller ones are made in the same way, but the smallest are drawn out into square rods and broken to the lengths required.

The gold tesseræ are made by taking heated plates of glass, three inches square, and covering their upper surfaces with gold leaf; then upon this is placed molten glass, which is pressed on with a copper plate till it forms only a thin even layer. They are next carefully annealed, and are then fit for use. The Byzantine character of the Russian mosaics involves a great cost from the large quantity of gold tesseræ employed.

In the Salviati process the drawing is made and coloured on paper, an adhesive surface is applied to it and then the tesseræ of comparatively thin glass are laid face downwards and adhere to the paper picture. The back is then covered with mastic cement which is pressed so as to fill in the crevices between the tesseræ, and to form a solid back, the whole of the back and sides are then enclosed in a zinc case and the whole becomes a perfectly firm plate, as compact as a slab of marble, only two thirds of an inch in thickness, instead of ten or twelve as in the case of Roman and Russian mosaics, and weighing hundredweights instead of tons.

The beautiful glass cloths resembling embroideries made of spun glass and beads shown by Tomassi e Gelsomini of Venice, together with their pretty tarsia and mosaic work, beads, artificial eyes, &c. obtained for them the merit medal. Several Venetian artists in mosaics only work up the smalts and form pictures, these therefore did not properly come within this section but were relegated to that of Fine Arts. As an illustration of the activity of the glass trade in Venice and Italy generally it is interesting to state that there were

no less than fifty-six exhibitors, many of whose names beside those above mentioned will be found in the list of recipients of the diploma of honourable mention in the Appendix.

Belgian Glass.

Though differing as widely as possible from the glass manufactures of Venice, those of Belgium were in their way not less remarkable. Altogether wanting in attraction to the general public was that ugly warehouselike framework which no doubt thousands thought a great disfigurement to the Grand Gallery, as it was called, of the Exhibition, but those plain sheets of glass, and those immense cylinders, were specimens of which our neighbours had good right to be proud, no other people in the world could have produced them. Belgium has always stood foremost in the manufacture of window-glass. The now general method of cylinder blowing which has taken the place of crown glass, took its rise in that country, and there it still attains its greatest perfection. With us a sheet of blown-glass five feet by three would be looked upon as large, but the Belgian glass-masters showed panes ten feet long by four wide.

The greater number of the Belgian exhibitors formed a collective exhibition under the title of the Association of Glass Masters of Hainaut, of which the Burgomaster of Lodelinsart, M. Léon Mondron, was president. As this gentleman was also a member of the jury the award could not be made to the Association over which he presided, consequently the individual members had to be considered and the following were awarded:—

Diploma of Honour.

Messrs. Bennert and Bivort, of Jumet near Charleroi, for window glass of the largest size and the finest quality.

Medals for Progress.

To Messrs. Léon Baudoux and Co., of Charleroi, for window glass coloured, plain, polished, engraved, ground, and stencilled, and to M. Alphonse Morel of Lodelinsart for white achromatic window glass of various thicknesses, prepared by a patent process of which he is the inventor.

Another manufacturer of Lodelinsart exhibited a remarkable series of specimens of window glass which were unsurpassed in the excellence of their quality and the great size of the sheets, namely M. Léon Mondron, who was

hors-concours in consequence of his being a member of the jury, in which his services were highly valuable.

To the Société Anonyme De Glaces et Verreries du Hainaut" at Roux near Charleroi for plate glass silvered and framed of large size. The polish on these mirrors was very fine. The largest was 4 metres by 2m. 80., the price being 50*l.*

Medal for Merit.

To Messrs. Andris-Lambert and Co. of Marchienne-au Pont.

To Messrs. E. Baudoux and Jonet of Lodelinsart.

To Messrs. A. Bougard, H. Lebrun, & Co. of Roux.

To Messrs. L. De Dorlodot & Co. of Lodelinsart.

To M. Alfred Fagniart of La Louvière.

To Messrs. Fourcault-Frison & Co. of Dampremy.

To Messrs. Victor Gorinflot, Gilson, & Co. Lodelinsart.

To Messrs. Schmidt-Devillez & Co. of Dampremy.

To Messrs. L. Lambert & Co. of Jumet.

To Messrs. A. Misonne & Co. of Dampremy; and

To Messrs. De Looper, Haidin, & Co. of Courcelles, all for window glass; the last showed sheets of extraordinary size.

To the "Society Anonyme de Courcelles pour la fabrication des glaces," for mirrors cut in new patterns.

To Messrs. Laurent, Maiglet, and Lessinnes of Binche for excellent table glass. To Mr. J. B. Ledoux of Jumet for a great variety in size and shape of glass bottles. To M. Joseph Pierre Martaux of Lodelinsart for engraved glass in tasteful designs; and to MM. Auguste Nyssens et Cie. of Laeken for mirrors, some beautifully decorated by acid-etching, and others cut and bevelled after the old Venetian style.

German Glass.

Considering the vast extent of the German empire, neither the extent, or importance of the glass manufactures exhibited were remarkable. The first in importance was the Josephinenhütte-Glassworks of Count Ludwig Schaffgotsch. These large works, situate at Schreiberhau in Prussian Silesia, employ about 500 workmen. The articles manufactured are chiefly in ornamental glass, engraved, painted, and gilded. The most remarkable novelty in the extensive display from these works was a kind of avanturine glass of great beauty. It differed from the Venetian in the ground colour, which was a dark rich brown, and in the spangles of gold which

were much smaller and rounder in form. The same coloured avanturine was exhibited by Pietro G. Bigaglia, of Venice, at the London Exhibition in 1862, but it differed in the size and regular form of the gold spots, which were also much fewer than in that of Count Schaffgotsch. The diploma of honour was awarded to the collective exhibition of the Count.

Also to Herr Friedrich Siemens, of the "Siemens Glass-works" at Döhlen, near Dresden, whose important works were represented by models. The exhibits consisted of bottles, glass globes, lamp glasses, and similar articles of great importance, from the enormous extent to which they are produced by the manufacturer. Of wine bottles alone the annual out-put is four and a half millions, giving employment to 300 hands, and 8-horse steam power.

The progress medal was given to the great Alsace and Lorraine firm of Vallerysthal. This is one of the largest of Continental glass works, employing 900 hands, and steam engines to the extent of 119 horse-power, besides the water-power obtained from four wheels and three turbines. This firm does a large export trade, amounting annually to about 30,000*l*. The colourless and ground crystal, and variously coloured glasses for decoration and table use, were all excellent and in good taste, and well sustained the early reputation of this firm, acquired under its founder Baron Klinglin. And to "The Silesian Mirror Manufactory" for rolled and polished plate glass, with models of the polishing machinery employed.

Medals of merit were awarded to the following exhibitors.

To Herr Fritz Heckert, of Petersdorf, near Warmbrunn, in Silesia, a comparatively new maker of ornamental glass, established as recently as 1866, but now employing 130 workmen and a small steam engine, and producing about 6,000*l*. worth of ornamental and table glass annually. Some of the specimens of gilded glass were very beautifully and tastefully executed, and his mirrors were of good quality and fine polish.

To the Albertinen Glass Works Company, at Charlottenburg, near Berlin, for the manufacture of glass bottles for the home and foreign wine trade, and other kinds for various purposes. The estimated annual production of this large establishment is about twelve millions of bottles, worth 80,000*l*., of which they export one-half. They employ 400 workmen. The bottles exhibited were in great variety, but made with much precision and neatness of workmanship.

To Messrs. Reckmann and Græbe, of Bielefeld, for excellent sheet glass. They also exhibited a model of a glass-

furnace, which was included in the award. It was a modification of Siemens', and claimed to be more easily and economically worked. But the model was ill made and too small to be of much use in forming a judgement of its merits. It was stated that it represented the furnace in which the exhibited glass was made.

To Messrs. Siegward Brothers and Co., of Stolberg, near Aix-la-Chapelle, for blown glass-ware and coloured glass enamels. This is one of the oldest glass firms in Germany, dating back from 1795, and manufactures almost entirely for home use. They employ besides 400 workmen, steam power to the extent of 20 horses.

To the Count Solms-Baruth, of Baruth, in Brandenburg. This is actually the oldest of German glass works, having been in active operation a century. The manufactures exhibited were noticeable chiefly for their general goodness and cheapness, consisting of ordinary window and plate glass, and especially lamp-glasses. The works give employment to 345 hands, a 10-horse power steam engine, besides water-power.

To Messrs. Stallmann, Itzenplitz, and Schlafhorst, of Mühlheim, for rolled plate window glass, bell glasses, glass globes, &c., of which they are large producers, and employ about 112 hands, and a small amount of steam power.

To Messrs. Villeroy, Boch, Karcher, and Co., of Wadgassen, on the Saar, for pressed glass and decorated household glass of good quality.

To Herr Eduard Vopelius, of Sulzbach, near Saarbrücken, for plate-glass. This is a considerable firm, employing about 200 hands and a 12-horse power steam engine.

To Herr A. Wagner, of Saarbrücken, for window glass, etched and stencilled, for grisaille and enamelled glass for church windows. The flashed sheet-glass exhibited was very even in surface and pure in colour. There are three distinct works in this establishment, one of which is exclusively for bottles, of which they manufacture immense numbers. In 1871 they produced 2,800,000 wine bottles, 206,000 square metres of plate glass, and 12,500 square metres of ornamental window glass, chiefly for churches. They give employment to 340 workpeople, and two steam engines of 20-horse power.

To Messrs. Wisthoff and Co., of Königssteele, Westphalia, another large firm, whose exhibits were of the same character and kind, that is wine and other bottles, globes, glass shades, sheet-glass, cathedral window glass, &c. They employ 292 hands and steam engines of 30-horse power.

To Herr E. Hug, of Dreibrunnen, for watch glasses, and to Herr G. Avril, also of Dreibrunnen, in Alsace-Lorraine, for watch glasses. This last is a very large establishment, employing 460 hands, three steam engines of the aggregate amount of 70-horse power, and a 15-horse power water-wheel.

One of the most noteworthy displays of glass of the useful kind was that of Ferdinand von Poschinger, of Buchenau, near Zwiesel, in Bavaria. It consisted of blown and plate-glass, sheet-glass, watch and clock glasses. The whole of the fuel used is wood. The works give employment to 307 hands, and water-power equal to 152 horses. Owing to Herr Poschinger being a juror his very meritorious exhibition could not be rewarded.

The medal for good taste was given to Herr F. Georgi, of Charlottenburg, near Berlin, for very clever glass flowers, fruits, and beads. He employs 33 men, and both his work and his name have a smack of Italian about them, which rather reminded the examiners of Venice.

Altogether the German glass was chiefly noteworthy from the cheap and useful point of view, and not from the artistic. A reference to the list of awards (Appendix B.) will show that many received the diploma of honourable mention, and there were others who received no reward. Altogether there were 63 exhibitors and an immense quantity of material shown, proving that it is a very large trade indeed in Germany, especially in the commoner kinds of glass.

Austrian, Hungarian, and Bohemian Glass.

In extent this part of the exhibition was the greatest which has ever been seen. The immense court in which it was placed was filled above and below; above with innumerable chandeliers, many of the most beautiful and elaborate designs, hanging so as to form a roof of glass over the spectator. Below, the crowded stalls covered with their dazzling treasures of every hue, formed a spectacle so startling in its beauty, that to thousands it will be the best remembered part of the Weltausstellung. But when the first feeling of astonishment gave way to the desire to examine in detail, the same satisfaction was not felt, for the Bohemians, although admitted to be the best glass workers amongst the continental nations, excepting the Venetians, more frequently than any others seem to forget the nature of the material, and ignoring its beautiful transparency, cover it with opaque surfaces and decorations, which render

it more like porcelain than glass. Moreover, they lose sight of that wonderful facility with which it can be made to take the most fanciful, light, and graceful forms, and work it rigidly into conventional shapes, very generally with rigid perpendicular outlines, the very opposite of what its easy swelling under the power of the human breath and the flexible manipulation of the human fingers seems naturally to dictate. These remarks apply chiefly to the continuations of the old German beaker forms and others made in the same style. When more classical forms are chosen for vases, &c. then another fault is almost always present, heaviness. They are massive in substance and heavy in decoration. The Venetian's idea is a bubble blown and moulded into the most fanciful form which his mind suggests in the brief period during which his material can be moulded. The Bohemian seems to think that glass is a material in which he can imitate porcelain. The greatest point of interest in the Bohemian glass is its strictly national character; and it is certainly most beautiful when kept within what we may call its natural limits, for in the numberless efforts to escape from that barrier, which could be seen in the exhibition, there was a deterioration rather than an improvement in the effect produced.

The Diploma of Honour

Was awarded to Messrs. J. Schreiber and Nephew for their decorated table-services, crystal services, chandeliers, and lustres of crystal glass of great purity of material and elegant designs. This is the oldest and most extensive of all the Austrian glass manufactories. It consists of five separate establishments, *Gross-Ullersdorf* in Moravia, *St. Sidonia* at Brumov in Hungary, *St. Stefan* at Brumov in Moravia, *Marienwald* at Proseë in Bohemia, and *Josefsthal* in Svètlà in Bohemia. At their several works there are schools, savings banks, insurance clubs, and dispensaries, altogether they employ 2,500 workpeople. There is scarcely any kind of glass article which they do not make, and the splendid gasaliers of the Grand Opera House at Vienna and other great theatres are examples of their work.

The Medal for Progress

To "the Collective Exhibition of the North Bohemian "glass and small ware industries," carried on in Gablonz, Wiessenthal, Morchenstern, Tiefenbach, and Polaun. This remarkable assortment contained a vast number of useful

things in glass, &c., from a bead or button, up to drinking vessels, &c., many of the articles showing great cleverness in manufacture and all remarkable for cheapness.

To Count Franz Harrach, of Neuwelt, Bohemia. The works of Count Harrach are amongst the most important in the country for the production of richly decorated ornamental glass. The colours are perfect, especially the transparent ruby, blue, and green, the opaque light turquoise blue, of which there was a great display, and the pure white and mottled, or marbled were most beautiful. Some of the table services were truly magnificent.

To Herr August Erben Hegenbarth of Hayda, Bohemia, for blown glass ware and painted beakers and drinking vessels.

To Messrs. Franz König, Palme, and Co. of Steinschönau, Bohemia, for blown and cut, plain and coloured glass; the beautiful polish on the cut glasses was much admired and gained them the award.

To Messrs. S. Reich and Co., Imperial and Royal Glass Works in Bohemia, Moravia, and Vienna. This company made a very grand show of every variety of glass ware from the cheapest to the most costly. The most noticeable were their chandeliers, which were of elegant designs and very pure in colour, quite worthy of the award of the jury.

To Herr Heinrich Ullrich of Vienna; an extensive manufacturer of all kinds of useful and ornamental glass, but the most noteworthy part of his display was the excellent ordinary glass which he makes in great quantity for exportation.

To Messrs. Josef Conrath and Co. of Steinschönau, Bohemia, for gilded and enamelled glass. This firm pay especial attention to gilding, and many of their examples testified to the remarkable excellence of their artists. Nor were they surpassed in the beauty of their paintings which were in the highest degree artistic.

To C. Stölze's Sons, of Nagelberg Schrems, Lower Austria, for fine quality of crystal glass. In common with all the exhibitors of clear glass in the Austrian department, this firm's exhibits showed that great improvement is taking place in the manufacture of this kind of glass, although they are still far behind the English glass in purity and brilliancy.

To Julius von Brunfaut of Vienna. The articles shown by this exhibitor differed widely from all the preceding, and belong to a class which however pretty and ingenious do not deserve much encouragement. They consisted of a

great variety of objects such as mats, baskets, and even bonnets made of spun glass. Similar works have been shown in previous exhibitions.

To Son of Andreas Ziegler, Sofien-glass works at Klentsch, Bohemia, for mirror plates, rolled plate, roof lights, &c. The careful polish of the mirror plates attracted attention, and the common rolled plate was of good quality.

To Josef Légrády of Ottaking, near Vienna, for facetted glass cut by a new process of which he is the inventor, but which he did not describe. The work was very beautiful in polish and the facets made with great decision.

To the Elbogen technical-chemical manufactory, Bohemia, for enamels and other chemical materials used by the glass works. This series of products belonged more properly to Group III. The enamels alone belonged to the glass section; these are made extensively by this firm, who supply the greater number of the glass workers of Bohemia with them.

Medals for Merit

Were awarded to "The Voitsberg Glass-work," Steiermark, Austria, for blown glass, and for sheet and plate glass of good quality.

To Herr Johann Hermann Adam, of Blottendorf, near Haida, in Bohemia, for coloured and plain glass ware, chiefly of an ornamental character.

To Messrs. Konrad Bodenmüller and Son, of Hurkenthal, Bohemia, for finely coloured glass objects. This firm also exhibited common mirrors.

To Messrs. Frenzl and Walter, of Steinschönau, Bohemia, for candelabra and chandeliers with bronze fittings, well made and in good taste.

To Messrs. Grohmann & Co., of Haida, in Bohemia, for blown coloured glass table services, drinking cups, vases, &c.

To the Heiligenkreuz Glass-works, Bohemia, for plate-glass.

To Herr Elias Palmer, of Steinschönau, for a general collection of ornamental and useful blowing glass wares.

To Herr Anton Pelikan, Haida, Bohemia, for a very choice collection of decorative glass.

To Herr Clemens Rasch, of Ulrichsthal and Meistersdorf, Bohemia, for a similar collection of coloured decorative glass.

To Herr Adalbert Scheinost, Haida, Bohemia, for the decoration of glass. As an artistic display the works of this exhibitor were well worthy of notice.

To the glass works of the Count von Seilern, at Josephsthal and Gaalthof, in Lower Austria, for blown glass, chiefly

for domestic use, also window and plate glass, neither of a high quality.

To Johann Sorger, Vienna, for a general collection of ornamental glass.

To Messrs. Stelzig, Kittel, & Co. of Steinschönau, for general glass wares.

To Messrs. Josef Zahn & Co. of Steinshönau for coloured Bohemian glass.

To Herr Jacob Mallman, Vienna, for a large collection of mirrors for which this firm formerly under the name of Johann Liebig & Co., has obtained a great reputation.

To Herr Ludwig Moser, Carlsbad, Bohemia, for manufactures in clear or crystal glass of good quality chiefly for house use.

To Herr Ziegler, of Kreutz-hütte, Bohemia, for mirrors and plate glass.

The general character of the Bohemian glass was so similar that it would have been difficult if not invidious to endeavour to point out any special distinctions in the various exhibits. If one exhibitor excelled another in one point, it was usually compensated by some superiority on the part of the other. The greatest merit was in producing the greatest variety of beautiful objects, and in this respect the most important exhibitor, Herr Lobmeyr, glass maker to his Imperial and Royal Majesty the Emperor, has not been mentioned because as a juror he was not entitled to compete. He, however, did good service as president of the glass jury, and as an exhibitor he fully sustained the high reputation his firm has for a long time past enjoyed, and the prizes he received in 1862 in London, in 1867 in Paris. All who studied those exhibitions will remember with pleasure the beautiful collections of Herr Lobmeyr, but at home he had another duty to perform, and another object to gain: it was to sustain the reputation of his country, and throwing aside the certainty of reward he produced such a display of the works of his numerous and highly skilled artists, that Austria had just cause to be proud of his work, and he has good cause to be satisfied with the universal admiration they excited.

Hungarian Glass.

This branch of the Austrian department was not very remarkable, some medals of merit were given to those makers who deserved credit for fostering the trade in their country, and for producing creditable manufactures. These firms were Johann Kossuck, of Pesth, Stephan Kuhinka & Son, of

Neu Anthonsthal, and Bonhád Palme & Co., of Zvečevo, and Herr J. G. Zahn, of Zlatnó, who deserves especial mention for his peculiar manufactures. This exhibitor sent to the London Exhibition in 1862 some glass plates and drinking cups which by their great novelty excited much surprise. They were beautifully iridescent, indeed as much as some of the finest specimens of antique glass. The writer showed some of them to the late Sir David Brewster, who had written much upon iridescence in glass and was under the impression that nothing but extreme age and special conditions could produce it. To him as to others this iridescent glass was therefore a complete puzzle. This year Herr Zahn had a large case filled with this wonderfully iridescent glass blown into handsome shapes for table use, the decanters having the beautiful appearance of soap bubbles when most brilliantly iridescent. The reporter was informed that the effect is produced by plunging the article whilst still very hot, but not soft, into a bath of melted tin. Apart from the iridescence, H. Zahn's glass was very good.

Medal for good taste.

Two of these medals were awarded in the glass section to Austria. One was to Herr Wilhelm Hoffmann, of Prague, for his exquisite engraving and painting on glass; his two fine vases were amongst the most elaborate and beautiful productions of the Exhibition. The other was to Herr Josef Ahne, of Steinschönau, also for painting on glass. These two painters are quite masters of their art, and it is to be regretted that they are not working on a fitter material.

Russian Glass.

The very beautiful works of the Imperial Fabrik at St. Petersburg were awarded the diploma of honour; their Slavonic or Russo-Byzantine character is their great charm, and it was a matter of regret that this character was being so obviously intruded upon and Bohemian tastes being substituted. At the Paris Exhibition of 1867 the Russian glass from the Imperial Fabrik was universally admired and coveted, but although many of the specimens shown in Vienna were equally good, many others bore the traces of innovation. The Slavonic style resembles the Persian in its fitness for glass decoration, and is better than the Bohemian; to copy the latter is therefore a mistake.

The brothers Guillaume and Eduard Gordliczka, of Tschechi, in the government of Siedlce, exhibited some very fair crystal glass, for which a progress medal was deservedly awarded.

And the medal for merit was given to Messrs. Amelung and Sons, of Dorpat, for mirrors.

The magnificent mosaics of Russia were very properly classed with the Fine Art collections, and therefore cannot be treated here.

Greece had two exhibitors of glass, but as they only received the lowest reward, their names will be found in the Appendix in the list of honourable mentions.

In the Japanese department there was a small collective exhibition of glass, both coloured and plain, also some which was polished. It indicated a good knowledge of the manufacture, and was rewarded with a Medal of Merit.

APPENDIX A.

List of Jurors in Group IX., Section C., Glass.

President.

Herr Ludwig Lobmeyr of Vienna.

Vice-President.

Herr Georg Benedict Von Poschinger, of Bavaria.

Professor T. C. Archer. Great Britain.
Herr Von Cohausen. Germany.
Herr Franz Krause. Austria.
M. de Luynes. France.
K. Notomi. } Japan.
K. Ogata. }
M. Kroupski. Russia.
Dr. Eduard Schmidt. Vienna.
Herr Philip Schou. Denmark.
Herr Ernest Szumrák. Hungary.

APPENDIX B.

Awards of the Jury in Section C., Group IX. Glass Manufactures and Enamels.

Cat. No. Diploma of Honour.

22. M. Charles Feil. Paris. Optical glass.
222. Gräf Schaffgotsch, Josephinenhütte. Prussia.
16. Imperial Glass Factory. St. Petersburg.
140. Salviati & Co. Venice.
340. J. Schreiber & Nephews. Vienna.
226. Siemens Glashüttenwerke. Döhlen, near Dresden.
1817. The Manufactory of St. Gobain. France.
327. Messrs. Bennert & Bivort. Belgium. Window glass.
713. Adolph Meyr's Nephew. Near Winterberg, Bohemia.

Medal for Progress.

224. The Silesian Looking-glass Manufactory. Ober Saltzbrunn-Silesia, Prussia.
145. Isaaco Bassano. Venice. Mirrors and mosaic work.
326. Leon Baudoux & Co. Charleroi, Belgium. Window glass.
68. Messrs. Bitterlin & Sons. Paris. Engraved glasses and mirrors.
69. M. Ph. Brocard. Paris. Oriental glass.
275. Julius von Brunfaut. Vienna. Spun glass Manufactures.
56. Group X. The Collective Exhibition of the North Bohemian Glass Industry.
72. The Glass Works of Rive de Gier. France. Polished and cast glass.

Cat. No.

278. Joseph Conrath & Co. Steinschönau, Bohemia. Glass enamelling and gilding.
324. The Chemical and Technical Manufactory of Elbogen in Bohemia. Enamel and lustre colours.
226. The Collective Exhibition of Crystal and Decorated Glass of the Portieux and Vallérysthal Glass works. Alsace and Lorraine.
23. Guillaume & Eduard Gordliczka, Brothers. Government of Siedlce. Russia. Polished glassware.
360. James Green. England. Fine glass work.
297. Count Franz Harrach. Neuwelt, Bohemia. Glass decorator by painting and grinding.
299. August Erben Hegenbarth. Haida, Bohemia. Glass painting.
518. König & Küpfer. Berne, Switzerland. Gilded glass.
306. Joseph Légrady. Ottaking, Austria. For a new process of glass cutting.
285. Fabrik. Glass. F. in Sophienhütte, Bohemia. Gas generating ovens.
89. A. Mercer. Paris. Large glass shades.
338. Alphonse Morel. Lodelinsart, Belgium. Window glass.
322. Franz König Palme & Co. Steinschönau, Bohemia. For brilliant polish of glass.
366. Pellatt & Co. London. Crystal glass and artistic cutting.
93. M. A. Pelletier & Sons. St. Just-sur-Loire, France. Coloured sheet and cylinder glass.
333. S. Reich & Co. Vienna. Glass ware.
340. The "Société Anonyme de Glaces et Verreries du Hainaut." Belgium. Mirrors.
353. Heinrich Ullrich. Vienna. Export glass wares.
104. Constant Valés. Paris. Imitation pearls.
360. Andreas Ziegler, Son of. Sofienhütte, Bohemia. Mirrors.
350. C. Stölzle, Son of. Nagelberg, Austria. Crystal glass.

Medal for Merit.

226. Administration of Count Solm's glassworks. Baruth, Prussia.
226. Albertinen Glasswork Company. Charlottenburg, Prussia.
226. Seigward Brothers & Co. Stolberg, Rhenish Prussia.
268. The Voitsberger Glass Manufactory. Steièrmark, Austria.
269. Johann Hermann Adam. Blottendorf, Bohemia.
59. M. Alexander the younger. Paris. Mirrors.
22. M. Amelung & Sons. Dorpat, Russia. Mirrors, and glass for mirrors.
324. Andris, Lambert, & Co. Marchienne-au-Pont, Belgium. Window glass.
106. Messrs. Appert Brothers. Paris. Enamels for porcelain painters, &c.
232. M. G. Avril, Dreibrunnen, Alsace. Watch glasses.
64. M. F. Bapterrosses. Paris. Glass pearls (solid).
325. E. & Jouet Baudoux. Charleroi, Belgium. Window glass.
13. Francesco Betti. Florence. Mosaic tables.
143. Pietro G. Bigaglia. Venice. Avanturine glass.
273. Conrad Bodenmüller & Son. Hurkenthal, Bohemia. Stained glass.
325*b*. A. Bougard, H. Lebrun, & Co. Roux, Belgium. Window glass.
70. M. Businger. Paris. Gilded glass beads.
12. Angiola Civita. Florence. Furniture mosaics.

Cat. No.
364. The Castleford, Aire, & Calder Glass Bottle Co. England.
— Cavaliere, G. Devers. Turin. Enamelled plaques.
74. J. Dopter & Co. Paris. Lithographic printing on glass.
329. Messrs. de L. Dorlodot & Co. Lodelinsart, Belgium. Window and cast glass.
370. The Glass Manufactory of Marinha-Grande. Leiria, Portugal.
342. The Manufactory of Count von Seilern Josephsthal & Galthof. Austria.
331. Alfred Fagniart, La Louviére, Belgium. Cast window glass.
332. Fourcault, Frison, & Co. Dampremy, Belgium. Window glass.
282. Frenzl & Walter. Steinschönau, Bohemia. Glass-ware.
287. The Heiligen-Kreutz Glass Works. Bohemia.
— The Japanese Glass Exhibition.
226. The Glass Works of Vopelius in Sulzbach.
333. Victor Gorinflot, Gilson, & Co. Lodelinsart. Belgium. Window glass.
293. Grohmann & Co. Haida, Bohemia. Glass painters.
321. Elias Palme. Steinschönau, Bohemia. Glass ware.
326. Anton Pelikan. Haida, Bohemia. Glass painting.
326. Ferdinand von Poschinger. Buchenau, Bavaria. Glass shades and stained glass.
95. Alfred Pottier. Paris. Enamels on copper.
146. Lorenzo Radi. Venice. Mosaics, calcedony, millifiori, &c.
330. Clemens Rasch. Ulrichsthal, Bohemia. Engraved glass.
96. Regat Fils. Paris. Imitation gems.
151. Cavaliero Luigi Romoli. Italy. For pictured looking glasses, painted by new process.
337. Adalbert Scheinost. Haida, Bohemia. Ornamental glass.
338*b*. Schmidt-Devillez, and Co. Dampremy, Belgium. Window glass.
142. "Società e fabricate unite di canne di Vetro e smalti." Venice. Glass beads and millifiori.
340. "Societé Anonyme de Courcelles, pour la fabrication des Glaces." Courcelles, Belgium. Cast glass.
344. Johann Sorger. Vienna. Drinking glasses.
226. Stallmann, Itzenpiltz, and Schlafhorst. Mühlheim on the Rhine, Prussia. Sheet, plate, and bell glasses.
347. Stelzig, Kittel, and Co. Steinschönau, Bohemia. Refined glass.
226. Messrs. Beckmann and Græbe. Westphalia Plate Glass Works. Bielefeld, Prussia. Sheet and plate glass.
136. Tommasi e Gelsomini. Spun glass and mosaics.
103. Tapart, Brothers. Paris. Imitation gems.
149. Gregorio Toso. Venice. Lustres and mirrors.
226. Messrs. Villeroy, Boch, Karcher, and Co. Wadgassen on the Saar, Germany. Moulded and decorated glass.
226. A. Wagner. Saarbrücken, Prussia. Plain and coloured glass.
226. Eduard Vopelius. Sulzbach, Prussia. Sheet and plate glass, shades, &c.
340*f*. Antoine Walravens. Brussels. Glass engraving.
226. Wisthoff and Co. Westphalia. Retorts, flasks, and cathedral glass.
43. George J. Zahn. Zlatnô, Hungary. Crystal glass.
358. Joseph Zahn and Co. Vienna and Steinschönau. Glass ware.
148. G. Zechin and A. Ceresa. Venice. Venetian glass wares.
361. Herr Ziegle. Kreutz hütte, Bohemia. House glass.
78. Gugnon and Sons. Paris. Glass decorators.
— Gwosdjet. Russia. Mosaics.

Cat. No.
223. Fritz Heckert. Petersdorf, Prussian Silesia. Mirrors.
226. E. Hug. Dreibrunnen, Alsace. Watch glasses.
82. P. C. Hugedè. Paris. Letters, &c. in glass.
303. Count Erben Carl Kinsky. Bürgstein, Bohemia. Mirrors and mirror frames.
37. Johann Kossuch. Buda-Pesth. Clear glass.
38. Stephen Kubinka and Son. Neu-Antonsthal, Hungary. Glass ware.
333. L. Lambert and Co. Jumet, Belgium. Window glass.
334. Laurent, Maiglet, and Lessinnes. Binche, Belgium. Table glass.
340. Ledoux, Ph. Charleroi, Belgium. Glass bottles.
330. De Looper, Haidin, and Co. Courcelles, Belgium. Window glass.
311. Jacob Mallmann. Vienna. Mirrors.
335. Pierre Joseph Martaux. Lodelinsart, Belgium. Engraved glass.
336. A. Misonne and Co. Dampremy, Begium. Window glass.
363. E. Moore and Co. South Shields, England. Pressed glass.
315. Ludwig Moser. Carlsbad, Bohemia. Glass cutting.
340*e*. Auguste Nyssens and Co. Laeken, Belgium. Glass ware.
139. Luigi Olivieri. Venice. Mosaics.
45. Palme Bonhâd, and Co. Zvečevo, Hungary. Common and polished glass.
137. Fuga, Angelo. Murano. Venice. Mirror.
340*b*. Lefèvre Frères. Lodelinsart, Belgium. Glass bottles.
339. Schmid, Josef Eduard. Aunathal, Bohemia. Engraved glass.
356. Weidlich Sebastian & Co. Steinschönau, Bohemia. Glass decorations.

Medal for Good Taste.

226. F. Géorgi. Charlottenburg, Prussia. For glass flowers.
390. Wilhelm Hoffmann. Prague. Glass decoration.
270. Joseph Ahne. Steinschönau, Bohemia. Painting on glass.

Honourable-Mention Diploma.

226. Actiengesselschaft, Carlshütte, in Gnarrenburg, Hanover.
60. M. E. Aubriot. Paris. Mirrors.
61. M. L. Audy. Paris. Glass pearls.
229. Bettmann and Kupfer. Bayreuth, Bavaria. Glass pearls.
150. Bormioli and Brothers. Parma. Bottles, vases, &c.
493. F. Brusewitz. Limmared, Sweden. Blown glass.
144. Domenico Bussolin. Venice. Venetian glass.
15. M. Casademunt. Barcelona, Spain. Glass wares.
266. H. Constantin and Co. Alsace. Watch glasses.
242. The Glass Works of Ralli. Attica, Greece. Glass ware.
241. The Glass Works of Skylitzi-Theologi. Piræus, Greece. Glass ware.
284. The Brothers Feix. Albrechtsdorf, Bohemia. Polished glass.
226. Leo Gasteiger and Co. Wolfrathshausen, Bavaria. Glass bottles.
228. Geck and Vittali. Ogerburg, Baden. Church window glass.
283. August Geiger. Kramsach, Tyrol. Glass wares.
292. Franz Graf. Grinzing, Austria. Bent glass.
296. Ignaz Hackl. Vienna. Glass ware.
226. Carl Hildebrand. Munich. Stencilled glass.
81. Hue and Co. Paris. Designs for glass decoration.
301-302. Joseph Inwald. Deutschbrod, Bohemia. Glass ware.

Cat. No.
36. S. D. Jeszenszky, and D. S. Both. Csókás, Hungary. Glass ware.
84. G. de Koepff. Paris. Glass beads.
20. Alexandrine Kostereff and Sons. Vladimir, Russia. Glass bottles.
18. Kostereff Nicéphore, Nicholas Ivan, and Wladimir. Moscow. Glass bottles.
312. Mayer and Hertle. Haida, Bohemia. Decorative Glass.
226. The Brothers Müllensiefen. Westphalia. Glass, beads, &c.
152. Nardi Ranièri and Brothers. Monte Lupo, Italy. Blown glass.
319. J. Neumann. Vienna. Glass works.
155. Professor Francesco Moretti. Perugia, Italy. Glass ware.
325. Emanuel E. Pelikan. Haida, Bohemia. Glass engraving.
327. F. Platenka. Dubnian, Bohemia. Glass bottles.
226. Hermann Georg and Dr. Ludwig Prossinagg. Steinmark, Austria. Blown glass.
226. Putzler Brothers. Penzig, Prussian Silesia. Lamp glasses.
226. Carl Röhrig. Brunswick. Stencilled sheet glass, mirrors, &c.
226. A. and W. Schell. Offenburg, Baden. Stencilled and engraved coloured glass.
226. Adolph and Thura Carl Schroeder. Hamburg. Curved and facetted glass.
138. Coen Stiffoni and Co. Venice. Beads and millefiori.
230. Teuscher Brothers. Bayreuth. Glass beads.
19. Andreas Titoff. Rostov, Russia. Enamel pictures.
340. F. Vanderborght and Co. Boussu, Belgium. Crystal blown glass and lamp glasses.
105. M. Vimont. La Pierre par Bouloire, France. Retorts and glass utensils for chemists.
226. H. Wentzel and Son. Frederichsthal, Prussia. Glass bottles.
226. Moritz Wentzel. Breslau, Prussia. Glass cutting.
357*a*. Hugo Ed. Wolf. Iglau, Moravia. Silvered glass, vases, &c. and polished crystal glass.
42. Anton Woticzky. Alt-Antonsthal, Hungary. Sheet glass.
355. Warzel, Franz. Haida, Bohemia. Wares in crystal glass.
153. Arimondi Fratelli & Co. Leghorn. Glass wares.
274. Bloch, Isaak. Hartmaine, Bohemia. Glass leaves for mirrors.

APPENDIX C.

List of Artisans who received the Medal for Co-operation.

The Salviati Company, Venice.

Antonio Aeguso. Foreman of glass blowers.
Prospero Ancona. Artist for chandeliers and lustres.
Leopoldo Barzotti. Foreman of decorators and gilders.
Giovanni Berovièro. Chief artist.
Giuseppe Berovièro. Designer and artist.
Giovanni Cazzatto. Designer of mirror frames.
Pietro Cazzatto. Foreman of mirror framers.
Giuseppe Cazzatto. Decorator of mirrors.
Domenico Giobbe. Foreman of marquetrie mosaics.
Giuseppe Mosetti. Foreman of the technical department.
Vittore Zanetti. Overseer of the works.
Francesco Novo. Foreman of monumental mosaics.

MESSRS. J. AND L. LOBMEYER. IMPERIAL AND ROYAL GLASS MERCHANTS, VIENNA.

A. Beer. Figure painter.
F. Boch. Figure painter.
J. Böhm. Flower painter.
Ambros Egermann. Heraldic painter.
Peter Eisert. Ornamental engraver.
Wilhelm Krulik, Junr. Manager.
Carl Pitsch. Figure engraver.
Marie Ritter. Designer.
Joseph Rudrich. Figure modeller.
Franz Shimpke. Enamel painter.
Rudolph Winder. Modeller.
Franz Woodwarzkà. Mounters.

MESSRS. AMELUNG AND SONS, DORPAT, IN THE GOVERNMENT OF LIVONIA, RUSSIA.

Dr. Benrath. General director.

THE IMPERIAL GLASS WORKS OF RUSSIA.

Leopold Bonaféde.
Sergius Petonhof.

HERR EDUARD VOPELIUS, SULZBACH, BY SAARBRÜCKEN.

Christian Koch. Glass blower.
Heinrich Koch. Sheet glass maker.

MESSRS. COPELAND, NEW BOND STREET, LONDON.

Mr. Oppitz. Glass engraver.

APPENDIX D.

GLASS MANUFACTURES exported from Great Britain in 1872.

Country.	Sheet and Plate Glass.		Flint Glass.		Common Bottles.		Kind not specified.	
	square ft.	£	cwts.	£	cwts.	£	cwts.	£
To Russia	47,956	4,702	1,754	4,747	9,916	4,977	—	—
Germany	109,458	12,141	9,247	17,592	10,770	4,233	2,581	5,796
Holland	67,370	6,819	1,973	4,454	—	—	1,667	6,550
Belgium	—	—	—	—	—	—	945	3,423
France	—	—	5,099	9,118	7,263	4,099	2,505	9,221
Portugal, including the Azores and Madeira.	—	—	—	—	25,295	8,863	—	—
Turkey	—	—	6,175	9,986	—	—	—	—
China	34,481	2,945	641	2,384	10,166	5,101	932	1,821
Japan	17,325	3,613	925	3,291	7,244	3,022	1,377	2,863
United States.—Atlantic.	1,309,326	139,715	6,170	30,878	69,438	34,561	51,267	62,218
United States.—Pacific.	16,346	1,832	219	1,865	10,232	5,006	10,731	14,369
Foreign.-West Indies.	—	—	5,517	11,386	48,545	24,133	—	—
Peru	—	—	1,495	6,416	44,412	22,166	—	—
Chili	—	—	1,695	5,643	26,197	12,842	—	—
Brazil	—	—	4,749	12,544	48,346	24,422	—	—
Hungary	—	—	1,642	4,095	7,075	3,552	—	—
Argentine Republic.	—	—	4,392	10,447	19,178	9,599	—	—
Channel Islands.	—	—	1,265	2,762	—	—	—	—
British Possessions in South Africa.	—	—	3,505	8,087	26,337	13,169	2,241	5,218
British India, Bombay and Scinde.	18,555	2,789	3,632	16,838	27,837	13,887	811	3,210
British India, Madras.	—	—	1,118	3,580	14,214	7,111	—	—
British India, Bengal and Burmah.	61,491	7,688	8,629	26,726	56,829	28,627	2,640	5,177
Straits Settlements.	—	—	786	2,282	—	—	—	—
Ceylon	—	—	961	3,155	—	—	—	—
Hong Kong	17,995	3,340	794	2,352	8,358	4,184	—	—
Australia	109,397	16,099	13,295	36,768	131,160	65,565	24,012	31,606
British North America.	92,605	14,110	9,377	23,662	51,060	23,277	11,169	16,460
British West Indies.	—	—	3,266	8,472	37,234	18,662	2,329	4,052
Other countries	229,619	27,387	12,683	30,951	63,730	31,479	13,451	32,608
	2,131,924	243,780	113,004	309,484	760,836	373,138	128,658	204,593

Mr. A. H. MOUNSEY.

SMALL WARES AND FANCY GOODS.

REPORT on GROUP X. and upon the INDUSTRY and TRADE of AUSTRIA-HUNGARY.—By Mr. A. H. MOUNSEY, Secretary to Her Majesty's Embassy at Vienna.

PART. I.—SMALL WARES AND FANCY GOODS.—Manufactures of Meerschaum, Tortoise-shell, Mother-o'-Pearl, Amber, Ivory, Horn, Bone, Whalebone, &c.— Combs and Brushes.—Toys, Waxworks, and Hand Mirrors.— Small Wares and Fancy Goods of Leather and Bronze —Japanned Goods.— Canes, Whips, Umbrellas and Parasols.

THE terms "Small Wares and Fancy Goods," "Articles "de Fantaisie," "Kurzwaare," embracing as they do a great many of the requisites, comforts, and ornaments of civilised life, all those products of industry, in short, to which the property of smallness is common, are exceedingly elastic, and the number of exhibitors in this class at the Vienna Exhibition fully corresponded with their comprehensive nature.

The general catalogue states the total number of exhibitors at 1,387, distributed as follows amongst the different nations of the world:—

United States of North America	10	Italy	27
Austria	583	Roumania	14
Belgium	2	Russia	16
Brazil	1	Spain	16
Denmark	6	Sweden and Norway	15
Great Britain	15	Switzerland	13
Colonies of Great Britain	1	China	5
France	59	Egypt	1
Germany	406	India	15
Greece	1	Japan	1
Holland	3	Persia	3
Hungary	31	Turkey	143

The jury, which had to decide on the respective merits of the multitudinous variety of manufactures exhibited by this long list of exhibitors, was composed to a great extent of gentlemen engaged in one or other of the industries of this class, and had the assistance of experts for those which were unrepresented.

The awards which it made have been published and a detailed account of the results of its labours is being drawn up by its Reporter, and will doubtless be communi-

cated to Her Majesty's Commissioners. For this reason, and more especially because I myself possess no special technical knowledge of the manufactures submitted to our verdict, I must confine myself to enumerating the principal products of each country in this class, as exhibited at Vienna, and to expressing in very general terms the collective opinion of my jury as to their respective merits.

The countries named in the above list may be, I think, not improperly distributed into the four following groups:

No. 1 comprises those countries which seem to be dependent on foreign manufacturers for most of the articles of this class.

No. 2 those which appear more or less capable of supplying their home demand for them, but which are probably not exporters of them, and have not attained pre-eminence in the manufacture of any of them.

No. 3 includes the East, which on account of the difference in the habits and culture of its inhabitants requires few of these articles, and manufactures others of a corresponding nature for its own use, and

No. 4 is composed of the countries which are pre-eminent in the manufacture of some, and large exporters of most of them.

In group No. 1, for which a very few words will suffice, the *United States of North America* only exhibited one case of tolerable brushes and some unnoticeable toys. *Brazil* merely a collection of exquisite artificial flowers* and fans of natural feathers. The *Colonies of Great Britain* a case of rhinoceros' horn sticks and some specimens of the ostrich feathers, largely exported from the Cape of Good Hope. *Greece*, a dozen or so of brushes, which need not be qualified, and *Roumania* nothing of interest beyond wax fruits of a certain merit, and some beautiful specimens of the black amber which is a speciality of that country.

The following countries appear to find their places in group No. 2, though some of them, probably on account of the distance, exhibited but a very small number of the articles of this class.

Denmark, which was awarded a Progress† Medal for japanned and turned goods, and medals of merit for ivory

* The flowers were of two kinds, of feathers nature colour, to represent simple flowers as cinerarias, pompons, poppies, &c., or in wreaths made from the breasts of humming birds, relieved in places by bettles wings of every shade from ruby to opal.

† The three Medals of Progress, Good Taste, and Merit were declared by the Presidential Council of the Exhibition to be co-equal, but whilst accepting this decision in theory the jury of Group No. X. practically gave the first rank to Progress; the second to Good Taste; and the third to Merit.

and wood carving, whilst its combs and paint brushes were honourably mentioned.

Spain, which obtained Medals of Merit for mother-of-pearl ornaments and wax works, and Honourable Mention for ivory sticks, and umbrella handles and fancy articles of shellwork from the Balearic Islands. No greater distinction than the latter could be awarded to the once famous fan manufacturers of Barcelona and Valencia.

Norway, which showed meritorious carving in wood, and *Sweden*, where progress has been made in japanned goods, and the manufacture of buttons has taken root.

Switzerland, which obtained a Progress Medal for brushes and combs, a Medal of Merit for fancy articles of ivory, and Honourable Mention for pipes.

Russia, which exhibited papier mâché wares and elaborately carved albums and nic-nacs in birchwood, the latter a specialty of the country, of acknowledged good taste, and received Medals of Merit for amber, bronzes, umbrellas and parasols and Honourable Mention for articles of various sorts in tortoiseshell, bone, leather, and lacquer. Its brushes and bristles, in which it carries on a large trade, appeared superior to any yet mentioned.

Belgium, whence come only two exhibitors, whose workmanship in caskets of a combination of ebony, bronze, and porcelain, was rewarded with a Medal of Merit.

Holland which, like Belgium, appeared inadequately represented, and only obtained a Progress and a Merit Medal for Japanned goods and Honourable Mention for brushes and bristles.

Hungary, which is commencing to assimilate some of the trades of its neighbour Austria, and bore off Medals of Progress and Merit for meerschaum and clay pipes, brushes, bristles, turned goods, and riding and driving whips, and was honourably mentioned for leather wares, ivory carving, bird cages, sticks, cherry pipe stems, and the quaintly painted "Kulacs" or wooden flasks, which are the constant companions of its agricultural population; and *Italy* which maintained its well known superiority in tortoiseshell ornaments of all sorts, from Naples, and obtained Medals of Progress for the umbrellas and parasols, which are largely manufactured at Turin, and the bronzes of Venice; and of Merit for ivory wares, especially billiard balls from Genoa, galvano-plastic wares from Florence, wood carving, travelling bags, wax imitations of fruit, fancy articles in leather, and brushes of rice straw.

At the head of the third group stands *Japan*. The excellence of its lacquered wares and the quaint, but always

graceful designs with which they are decorated are too well known to require comment. The specimens shown by the committee, which undertook to represent the country at Vienna, were superior in quality and number to anything of the sort in this, or any previous Exhibition and the highest distinction, a Diploma of Honour, was unanimously awarded to them. Hardly less meritorious was the collection of bronzes, especially of those in which the admirable correctness and gracefulness of the modelling and the perfection of execution are enhanced by the artistic taste with which the three metals, gold, silver and bronze are combined. Besides the Diploma conferred on the committee, several Medals of Progress and Merit were awarded to individual exhibitors for the small wares of the country, such as fans, tortoiseshell and mother-of-pearl buttons, parasols, artificial flowers and toys, all displaying the harmonious taste and minute and exact workmanship which seem to be common to all Japanese workmen.

China's principal exhibits were elaborately carved caskets, goblets, chessmen, fans, &c., in ivory, bone, and mother-of-pearl, and fancy articles made from the gorgeous plumage of Eastern birds. Its lacquered goods were medalled, but cannot compete in quality or taste with those of Japan.

Persia showed a large and fine collection, chiefly from Ispahan, the centre of this industry, of papier mâché book-backs, caskets, mirror-cases, and pentrays, covered with miniature paintings of scenes, taken from Persian life in the field or harem, birds and flowers, or arabesques most elaborately executed in gold and brilliant colours.

From *Turkey* there were no less than 143 exhibitors, most of whom exhibited but one single object. Red clay pipe heads, pipe stems, narghilehs, amber cigar holders, chaplets and rosaries of perfumed wood, and various articles in mother-of-pearl and cedar wood received Medals of Merit and Honourable Mention.

India showed caskets, card cases, pen-trays and other nic-nacs of sandal wood inlaid with ivory, unique of their kind; and the secretaries of the local committees of Bengal, Madras, Bombay, Mysore, and the North-west Provinces were awarded Medals of Merit for their collections of these objects, as well as for admirable miniature models of the natives of the different presidencies, whilst individual exhibitors received similar medals or were honourably mentioned for minutely carved objects of all sorts in ivory and for fancy articles made from the plumage of birds and the spoils of the chase, such as feather fans and tiger-jaw inkstands, &c.

The fourth group comprises the great manufacturing countries England, France, Germany, and Austria.

The manufactures of *Great Britain* in this class were sparsely represented. Her whips of all sorts were unanimously judged to be the best in the Exhibition, though the two cases exhibited did not contain the choicest specimens of the trade and the prices appeared high to continental jurors, and one case of brushes of every description was not surpassed by the similar produce of any other country. Her combs, gas fittings, japanned wares and fancy articles in bog oak, which had a considerable sale at Vienna, received Medals of Merit, but her other exhibits, chiefly jewelry cases and mother-of-pearl wares were not deemed worthy of more than Honourable Mention.

France had a larger number of exhibitors, and was pre-ëminent amongst all nations for bronzes, three of her manufacturers in this branch of trade having obtained Diplomas of Honour (one was awarded by the jury of group X. and two by the jury on metal wares) and several others having received Medals of Progress and Merit. It were useless to enumerate the numerous objects in this metal exposed to view by the French exhibitors, and it will suffice to remark that in every one of them, statues, candelabra, clocks &c., from the largest works of art, in short, to the merest trifles, elegance of design is combined with perfection of execution. In the manufacture of tortoiseshell snuff boxes, likewise, France appears to surpass all nations, and the taste displayed in her fans is unequalled elsewhere. Wherever this quality is requisite, her workmen seem to excel, whilst the results of their labours are always characterised by neatness and high finish. The other objects exhibited by France were rosaries and religious ornaments of ivory, box wood, cocoa nut, &c., brushes, lamps, toys, albums, portfolios, leather travelling bags, imitations of Japanese lacquer work, amber and imitation of amber (highly perfected), fancy articles and piano notes in ivory and bone, and lighting apparatus; and such had been the care taken in selecting them and excluding all that was insignificant that, out of the 59 French exhibitors, there were only three or four who were deemed unworthy of medals.

Germany is the largest manufacturer and exporter of small wares in the world. One quarter of her produce suffices for her home market, one quarter is exported to other European countries, and one half to North and South America and the East. An idea of the extent of her trade may be gathered from the fact that 50,000 persons (men, women,

and children) gain their livelihood by making the wooden and cardboard boxes in which these wares are packed.

As early as the middle ages, and especially during the sixteenth century, Nuremberg was celebrated for its small wares, and together with the adjacent town of Fürth it still continues to be the great centre of the trade. Toys of which there were no less than 42 exhibitors at Vienna, combs and brushes of all sorts, appear to be the staple industries of these two towns. Thus one single commercial house at Fürth last year exported 5,000 gross (1 gross = 12 dozen) of children's trumpets. Nuremburg manufactured paint and colour brushes of the value of 80,000*l.*, and the two towns produced 200,000 dozen combs for which 750,000 horns and 200 cwts of ivory were used. But besides these they possess factories which annually export the following articles by scores of thousands:—All sorts of ornaments of tortoise-shell, buffalo horn, horn, ivory, and amber, picture and mirror frames, jewel boxes, artificial jewelry, pipes, especially those of briar wood, an industry which seems to have emigrated from France since the late Franco-German war, kaleidescopes, sticks, whips, brushes, buttons, and hand and pocket mirrors of every species and description (60,000 dozen annually) as was manifest from the contents of the cases of 21 exhibitors.

Thüringen, Saxony, and Saxe-Meiningon are also great exporters of toys, and in the first of these provinces 25,000 persons are engaged in their manufacture.

The manufacture of small wares in metal and bronze is chiefly confined to Prussia, but this province is perhaps more celebrated for its amber trade, the principal centres of which are Königsberg and Dantzig. In the former town the Prussian Amber Company, limited, employs 2,350 persons and 19 steam engines in this trade, and sold amber, which is found by divers and dredging on the coasts of the Baltic, to the value of 53,000*l.* in 1871. A Diploma of Honour was awarded to this company for the extent of its trade and the excellence of its amber.

A similar honour was conferred on the house of Meyer of Hamburg, probably the largest manufacturer of whalebone wares and walking sticks in the world. The value of the produce of the former in 1871 was 362,000*l.* and the number of sticks and whips was 175,000 dozen, valued at 65,000*l.* The total number of walking, umbrella, and parasol sticks annually manufactured in the whole of Germany amounts to 2,000,000. Leipzig, Erfurth, Stuttgardt, and the Thüringian villages being, besides Hamburg, the chief seats of this industry.

The inhabitants of the Black Forest have been brush makers for more than a century. Introduced in 1760, brush-making has there become a household industry which occupies many hundred people. There are, besides, five large factories and several smaller ones which supply a great part of Germany with their produce, valued in 1871 at 80,000*l.*

The foregoing are the chief centres of the export trade, but besides these there are manufactures of small wares of one sort or another for home consumption in almost every town of importance in Germany. Thus umbrellas and parasols are made in large numbers at Pyrmont, where one factory alone turns out annually 10,000 dozen, Berlin and Aix-la-Chapelle. Buttons are produced in millions at Friburg (Baden), where nearly 4,000 persons find employment in this trade, at Magdeburg, Hamburg, and Berlin, and in Bavaria, Hesse Darmstadt, and Westphalia. Leather wares are largely manufactured in Frankfort and Offenbach (Hesse); brushes, in Berlin, Strasburg, Bonn, Posen, Striegau (Silesia), Altenburg, Dresden, Stettin, and Königsberg. There are large india-rubber factories at Harburg and in the Grand Duchy of Baden. The manufacture of agate cameos is extensive in Oldenburg. Magdebourg and Cobourg vie with Paris in the production of snuff boxes. Rosaries are made in large quantities in Catholic Bavaria, and ornaments and fancy articles of ivory, horn, &c. at Wiesbaden, Berlin, Munich, Hamburg, Erbach, and Michelstadt (Hesse).

Of the 406 German exhibitors above 250 received medals or were honourably mentioned, chiefly on account of the extent of their trade or the utility of the articles produced, for the German artisan seems less gifted with artistic taste than either the Austrian or the Frenchman, and this deficiency was apparent in many ways at Vienna, especially in the arrangement of the small-ware exhibition. On the other hand, the German catalogue was a model worthy of imitation by all for future exhibitions, being compiled with great care, and furnished with statistical data relative to the foundation of each factory, the number of the workmen and the extent of the steam-power employed, as well as the quantity and value of the goods produced.

Austria, i.e., Cisleithania (Hungary having been mentioned already) ranks after England and France as the most important rival of Germany in the small ware trade, and the imports and exports classified in the Austrian tariff under this heading, which, however, comprise only a certain number of the articles referred to above, prove a considerable

augmentation of productive and consumptive power since 1865. They were as follows:—

—	Value of Imports.	Value of Exports.
	£	£
1865 -	249,056	3,770,624
1866 -	282,159	3,623,874
1867 -	319,666	5,177,984
1868 -	530,405	4,907,214
1869 -	1,046,097	5,236,554
1870 -	1,141,944	4,447,713

Vienna is the principal centre of the trade, and the chief manufactures are those of meerschaum, amber, bronze, and leather.

Tobacco smoking is said to have been introduced into Germany and Austria by troops sent from England to assist the King of Bohemia during the 30 years' war about 1620. The first pipes used were the long clay pipes in one piece, still common in Holland and in the road-side inns of England; but in 1689 an Austrian medical man invented what is now generally known as the German pipe, consisting of a mouth-piece, stem, and bowl. Other materials than clay then came to be employed, especially wood, which afforded facilities for artistic carving, and this was supplemented about 100 years ago by meerschaum, then first brought to Pesth and Vienna by Turkish merchants.

It was, not, however, until 1830 or thereabouts, that the latter material became largely used, and it is only since the London Exhibition of 1851 that Vienna has become the largest manufacturer of meerschaum pipes in the world. The raw material, the richest beds of which are near the town of Eski-shehr in Asia Minor, but which is also found in the Crimea, Spain, Greece, and Moravia, is imported in cases weighing between 50 and 60 lbs., and the following figures show the increase of the imports and the fluctuations in the price of the article.

—	Cases.	Value per Case.
		£
1850 -	800	50
1855 -	3,000	60
1860 -	5,000	90
1865 -	8,000	35
1870 -	10,000	50
1872 -	12,000	35

From this material 100,000 dozen pipes, the carving of many of which entitles them to rank as works of art, and 500,000 dozen cigar holders are annually manufactured in Vienna and its neighbourhood alone by 154 masters and 800 workmen, whilst 26 masters and 200 workmen are employed in making amber mouth-pieces and ornaments. The latter substance is sold by weight, and the price varies according to the colour and size of each piece, from 10*s.* to 15*l.* per lb. The quantity used at Vienna in 1872 was 60,000 lbs valued at 160,000*l.**

Closely connected with the above industry is the manufacture of imitation meerschaum, from the chips and waste of the original material. 4,000 cwts. of the waste are annually consumed in the production of pipes, cigar-holders, &c., and the imitation has been carried to such perfection that connoisseurs sometimes find it difficult to distinguish these articles from similar ones of the genuine substance.

Cherry-wood pipe stems and cigar-holders are also largely manufactured at Vienna, the soil of the neighbourhood, especially near the small town of Baden, being excessively favourable for the culture of the cherry plant, in which 1,500 persons are engaged. If the large number of workmen employed in the manufacture of horn pipe fittings, narghilehs, and silken tubes be added to the above, it will be found that there are in and about Vienna 5,000 persons occupied in administering to the wants of smokers. No less than 73 exhibitors of the above-mentioned articles received Medals and Honourable Mentions, and their unequalled display of meerschaum and amber wares, which, like the whole of the Austrian compartment, was very tastefully arranged, prove that Austria still maintains her pre-ëminence in this industry.

In the manufacture of all those manifold articles which are comprehended under the German term "Leder galanterie-waaren" such, for instance, as travelling bags, albums, portfolios, cigar and card cases, purses, scent and watch stands, writing necessaries, and a host of other articles and nic-nacs, either of leather alone, or of a combination of leather, bronze, porcelain, &c., Austria, and especially Vienna, is justly celebrated. Since the Paris Exhibition of 1867 these wares are largely exported to France, England, and the United States,

* The most remarkable pipe in the Exhibition was, however, contributed by Josef Holländer, of Pesth, who presented it to the Magyar Ipar Museum, of his city, formed of an enormous piece of meerschaum, carved to represent a group of eight wild horses, and two herdsmen, the amber mouthpiece was of great length and beauty as a specimen piece, and amber was extensively let in with cameos, intaglios and carvings in relief into the body of the pipe. The carving of the group was most artistic and as a specimen both of meerschaum and amber alone, this pipe was unique even in this display, whilst its art merits deserved a place in the Kunst Halle.

and some 2,000 persons, besides 1,600 employed in the binding trade, are engaged in their manufacture in the capital alone, whilst Prague is likewise making itself a name for their production. 34 exhibitors were awarded medals and the contents of their cases, characterised by taste and good workmanship, formed one of the most ornamental sections of the Austrian compartment.

In the manufacture of bronzes, first introduced from Paris at the commencement of this century, Austria ranks next to France, and as regards elegance of design and correctness of execution appears quite able to compete with her French rival in all the smaller articles of this metal, such for instance as candelabras, writing table necessaries, caskets, &c. Vienna is the centre of the trade and possesses 12 large bronze factories and a number of smaller ones.

In her fans too, likewise an industry of recent date, Austria is second only to France, and seems quite able to hold her own in the manufacture of all sorts of turned goods (at Vienna there are above 2,000 persons employed in wood turning alone), parasols and umbrellas, buttons, toys, galanterie wares of ivory, horn, mother-of-pearl, and wood, glass pearls (principally from Gablonz in Bohemia), brushes, whips, sticks, &c.

A large number of medals were very properly distributed amongst the 583 Austrian exhibitors of the above articles, and it is evident that the import duties on many of them might be considerably reduced without any injury to their manufacturers. These duties are in many cases very high. Thus, those on fans, umbrellas, and parasols of woven textures amount to 7*l.* 10*s.* per cwt., those on fancy articles of meerschaum, amber, bone, and tortoiseshell, range from 5*l.* to 7*l.* 10*s.*, and those on leather and bronze wares from 1*l.* to 7*l.* 10*s.* per cwt.

In general, I think, it will be found that one result of the Vienna Exhibition will be that Austrian manufacturers will see that they can compete with foreigners in many branches of industry, and that they will be ready to accept reductions in the tariff of import duties without much opposition whenever they may be proposed.

PART II.

Some Remarks on the Industry and Trade of Austria-Hungary since 1865, and on the probable effect of the Vienna Exhibition on the Material Development of the Empire.

Opinions are much divided as to the general utility of such colossal and universal undertakings as the Vienna

Exhibition, and because the latter was opened when only half ready, and the sun did not shine on its inauguration, because soon afterwards a financial panic, the natural result of over speculation, caused people to look only at the black side of all things; further, because the exorbitant prices of rapacious hotel keepers, and the outbreak of cholera scared thousands of foreigners from the great fair, and finally because it is now evident that its receipts will not cover half the expense that has been incurred, it is considered a failure by most of those who have not seen it, and a mistake by many who have. Both of these opinions are, I think, erroneous.

A moiety of the above calamities would have sufficed to mar the success, in a pecuniary point of view, of any enterprize, but under the most favourable circumstances it is doubtful whether, when the original estimate of the cost of this Exhibition, viz. six millions of florins had risen to above three times that amount, even the sanguine originator of the scheme hoped to balance his expenses by his receipts. He was doubtless aware that the pecuniary success of the Paris and London Exhibitions was due, not to the influx of foreigners, but to the entrance fees paid by Frenchmen and Englishmen; he also probably knew his own country too well to presume that similar masses of visitors would be forthcoming from an Empire, which is composed of half a dozen different nationalities still clinging to their respective capitals, Prague, Graz, Agram, Buda-Pesth and Cracow, and unaccustomed as yet to regard Vienna as their common centre, and in which the means of easy and speedy communication are incomplete.

Hence, though the promotors of the Exhibition might fairly calculate on a larger concourse of foreigners, it is to be presumed that they looked beyond the direct question of making it pay, and anticipated that the State would ere long more than recoup its outlay, indirectly, by the benefits which would accrue to all branches of its industry, commerce, and agriculture. They may have reflected that the Austro-Hungarian Empire was not only little known beyond its frontiers, but that its own inhabitants were likewise ignorant to a great extent of the resources, capabilities, and requirements of its wide spread provinces, that Vienna stands, so to say, almost on the limits of civilized life and that east of t lie countries of vast natural resources which can only be developed by the introduction of new ideas, methods, and processes of culture.

The future alone will show whether the anticipations above referred to will be realised, but whether entertained or not by the projectors of the Vienna Exhibition, there is

much in the history of the development of Austro-Hungarian trade and industry to render them plausible if not justifiable.

Previous to the year 1851 the Austrian Tariff was one of the most exclusive in Europe. A less prohibitive commercial policy was then adopted and resulted in 1854 in a protective scale of duties which continued in force until 1865. During this decade the interests of consumers received a more proper meed of consideration, and liberal ideas on trade and many other things gained such ground that at its close a commercial treaty was concluded between Great Britain and Austria by which reductions, varying from 5 to 89 per cent. were made in the import duties of the empire, and it was stipulated that on and after the 1st of January 1870 the rate of import duty on the produce or manufactures of the United Kingdom should not exceed 20 per cent. of their value at the place of production; and as most other nations are, by the most favoured nation clauses of their treaties, now placed on the same footing, this stipulation forms the basis of the present tariff.

Under this tariff the progressive increase in the imports of the Empire has been as follows:—

	£		£
1865 -	25,075,379	1869 -	41,243,627
1866 -	21,138,215	1870 -	42,507,549
1867 -	28,645,242	1871 -	52,458,149
1868 -	37,653,303	1872 -	59,244,120

The chief sources of this increase were larger imports of 1stly; entire fabrics, viz., cotton, linen, woollen, silk, leather, iron and small wares, rails, machinery, chemical products, books and newspapers; 2ndly; of half fabrics of iron, tin, wool, and leather, of dies, gums, precious stones, chemical products, and meal; and 3rdly; of raw produce, viz., cattle, hides, bristles, tallow, wood, coal, raw iron and other metals, silk, rice, coffee, and cocoa.

That this increase has resulted from a corresponding increase of national wealth, and purchasing power, and has not been in any way detrimental to home industry and manufactures, would appear to be the inference to be drawn from the steady increase in the exports of the empire during the same period, which is apparent from the following table:—

	£		£
1865 -	34,068,134	1869 -	43,233,640
1866 -	32,622,530	1870 -	32,137,730
1867 -	40,389,575	1871 -	46,305,684
1868 -	42,537,339	1872 -	38,218,126

Here the increase is principally due to larger exports of most of the articles already mentioned as being more largely imported, viz., 1st, entire fabrics of cotton, linen, silk, cloth, leather, glass, and iron, of small wares, ships, sugar, and beer; 2ndly, of half fabrics of linen and leather, dies, chemical products, and meal; and 3rdly, of raw produce, viz., seeds, coal, minerals, rye, oats, cattle, and lard.

A clearer idea, however, of the trade of the empire will be obtained from the following table, which shows the excess of imports over exports,* and vice versâ, in 1872:—

Description of Articles.	Imports.	Exports.	Excess of Imports.	Excess of Exports.
	£	£	£	£
Colonial produce - -	3,085,525	1,780,821	1,299,712	
Tobacco and its fabrics -	2,368,994	647,907	1,721,087	
Agricultural and garden produce.	4,404,743	3,555,025	849,718	
Animals - - -	2,790,788	976,103	1,814,685	
Animal produce - -	1,760,392	1,301,418	458,974	
Tallow and oils - -	2,178,891	288,036	1,890,855	
Liquors and eatable substances.	514,522	499,065	15,456	
Wood - - -	2,262,836	3,300,956	—	1,038,119
Medicines, dies, perfumes, and half manufactured chemical substances.	3,758,958	635,349	3,123,609	
†Metals, raw and half manufactured.	4,171,012	506,010	3,665,002	
Raw material for spinning and weaving.	9,470,122	3,711,180	5,768,942	
Yarns - - -	3,742,421	1,245,670	2,496,751	
Spun and woven goods -	7,239,144	6,130,126	1,109,018	
Wares of hair, straw, paper, &c.	468,066	852,810	—	384,743
Leather, furs, leather and caoutchouc wares.	2,232,959	1,633,443	599,515	
Glass, wooden, stone and clay wares.	948,482	2,556,804	—	1,608,322
Metal wares - -	1,929,895	1,582,499	347,397	
Waggons, ships, &c. -	410,350	661,114	—	250,764
Instruments, machines, and small wares.	3,657,115	5,141,525	—	1,484,410
Chemical and oleaginous substances, dies, matches	589,975	672,675	—	82,700
Literary works and works of art.	1,227,665	442,585	785,080	
Rags and waste - -	36,256	97,006	—	60,749
Total - -	59,244,120	38,218,126	21,025,994	—

During the period under notice, 1865–1872, the customs receipts rose from 1,366,598*l.* in the former, to 2,783,519*l.*

* Exclusive of the trade of Dalmatia.

† Exclusive of silver and gold and coins of both metals.

in the latter year, being an increase of 1,416,921*l.*, and the progress of the empire as regards the numbers of its population, the produce of its taxes and of various branches of its industry may be gathered from the following official statistics:—

The total population of the empire was in—

1865		34,753,272
1872	Austria	20,727,164
	Hungary	15,417,327
	Total	36,144,491

The total number of miles of railway opened to circulation was—

1865	4,013
1873	9,158

and the receipts of the first nine months of 1873 exceeded those of the same period in 1872 by 835,857*l.*, *i.e.*, nearly two-thirds of the uncovered expenses of the Exhibition.

The indirect taxes rose from—

£

5,940,897 in 1865 to
6,596,101 in 1870.

The direct taxes from—

£

11,727,679 in 1865 to
12,623,118 in 1870.

The income tax, included in the latter, having produced 2,351,893*l.* in 1870, as against 2,007,909*l.* in 1865.

The quantity of coal exported has risen as follows:—

	Centners=110·25 lbs.
1865	7,713,240
1866	9,621,358
1867	14,615,576
1868	16,185,961
1869	16,414,711
1870	18,503,963

The number of beet-root manufactories and the quantity of sugar produced was—

	Factories.	Centners.
1867	151	17,913,451
1868	162	14,113,403
1869	181	21,895,632
1870	215	28,410,308
1871	251	24,291,475

The produce of sugar more than suffices for home consumption, and the exports which were valued at 671,569*l.* in 1865, rose to 1,732,605*l.* in 1870, a considerable quantity being, I am told, bought up by English merchants for exportation to the United States.

The quantity of beer brewed was—

	Eimers = 13 Imperial Gals.
1867 - -	12,881,847
1868 - -	13,984,132
1869 - -	15,480,474
1870 - -	16,685,491
1871 - -	19,043,766

and the value of the beer exported in 1870 was 200,227*l.* as against 91,079*l.* in 1865.

The quantity of iron ore melted in the iron districts of Cisleithania, viz., the provinces of Styria, Carynthia, Salzburg, Carniola, Bohemia, Moravia, Silesia, Galicia, and the Bukovine rose from—

Centners.
10,623,000 in 1867 to
17,279,308 in 1871,

and the quantity of iron produced in the whole empire from—

Centners.
6,160,000 in 1867 to
8,492,312 in 1871,

being an increase of 30 per cent. in five years.

The manufacture of iron in Cisleithania, I must here remark, labours under a serious disadvantage as regards fuel, most of the coal found in its provinces being unfit for coke-ing, and consequently useless for the production of iron. Coke has therefore to be brought at great expense from considerable distances, and this is one of the reasons why, notwithstanding the increasing supply of home manufactured iron, a large and increasing quantity, as apparent from the following figures, is still imported :—

	Iron imported. Centners.
1867 - -	294,635
1868 - -	2,627,666
1869 - -	3,091,912
1870 - -	3,220,167
1871 - -	3,863,689

There are many other trades and industries in which a notable development has taken place during the period here treated of.

Thus the number of flax spinning factories, which was 40, with 150,500 spindles in 1862, now amounts to 62 with 370,790 spindles, and the exports of linen wares have risen from 807,361*l.* in the former year to 1,503,892*l.* in 1870.

The manufacture of glass, which was first introduced into Austria from Venice in the reign of Marie Thérése and the produce of which is so well known throughout Europe and the East for its taste and cheapness, continues to prosper and expand, the exports, principally from Bohemia, having advanced from 1,296,299*l.* in 1865, to 1,857,745*l.* in 1870.

The manufacture of silk, notwithstanding the loss of Lombardy, whence the silk trade drew the greater part of its raw material, is in a flourishing state. In Lower Austria, the principal seat of this industry, there are now 165 factories, 119 of them being riband factories, and the exports are more than double what they were in 1861, the figures being,—

1861	-	-	420,208*l.*
1870	-	-	977,860*l.*

Finally, I may state that in 33 out of the 42 entire fabrics (Ganz fabricaten) which are subjected by the Austrian tariff to various rates of import duty, the exports have been steadily on the increase since 1865, and the inference would seem to be that Austrian manufactures, generally speaking, are now able to compete with those of other nations, and that, without injury to them, many of the duties might now be advantageously reduced in favour of consumers, amongst whom must be reckoned the 15 millions of inhabitants of Hungary.

The Austrians, and especially the Viennese, possess vigour, versatility, and a very considerable talent for adopting new ideas, forms, and methods, and as an instance of this celerity of adoption, I may observe that the production of steel by the Bessemer process which was first introduced in Upper Styria in 1864 has risen from 6,115 centners in that year, and district, to 1,356,656 in 1872. Though not perhaps gifted with great powers of original invention they, nevertheless, contrive to introduce new features where they copy and thus prevent their creations being simply servile imitations. The industrial classes will have observed and learnt much that was new to them during the last six months, and, with these qualities, it is more than probable that they will turn the knowledge thus acquired to good account. They have now had before them samples of the most perfect manufactures in every branch of industry, they have seen at the

Vienna Exhibition what they can do, and where they are behind-hand—their capabilities and their deficiencies—and the knowledge of the former will doubtless have encouraged them to study and profit by the means which it has afforded them of correcting the latter.

The increase of material wealth and the industrial progress which may be inferred from the foregoing figures and data, and which may fairly be attributed to a great extent to the realisation of the new idea of a liberal commercial policy, has, however, taken place almost entirely in the Cisleithanian provinces of the empire, which, by their geographical position and through their large German population, have ever been closely connected with Western Europe, and are consequently far ahead of the provinces of the Crown of St. Stephen in all the arts of civilisation. In the latter, there is a much wider field for, and a much greater need of, industrial and commercial enterprise.

A very few years have elapsed since Hungary first started on the path of modern culture; it may be said, indeed, that it was not until 1867, when the political claims of the Magyars were finally adjusted to their satisfaction by the establishment of the present dual system of government, by which they acquired almost complete autonomy, that the Hungarians began to turn their attention seriously to the development of the material resources of their country. Individual efforts had been previously made by men like Szecheny to introduce the inventions and appliances of modern civilisation, but it was only in 1867 that the nation became thoroughly aware of their necessity, and sought to issue from the lethargy in which it had so long slumbered.

In its enthusiastic joy at becoming mistress in its own house, it thought to rise at once to the level of the most civilized countries in Europe, to do in years what had only been done in scores of years elsewhere, and to become a great nation in no time. Impelled by these feelings and aspirations the Government took the initiative, and the construction of railways became its chief object. Several main lines of great utility were at once planned and speedily constructed, above 800 miles of railway having been made and opened in the years 1868, 1869, and 1870. Extensive and costly public works of all sorts, which, from a not altogether unpardonable desire to gratify the national vanity, were deemed necessary for the embellishment of the capital, were at the same time commenced, a large portion of the revenue was devoted to the organisation and maintenance of an army of Honveds or Landwehr, and a cabinet of no less

than ten ministers with a large staff of subordinate officials in each of their departments was thought necessary for the regeneration and administration of the country. Thus, though a considerable sum of money was set apart for educational purposes, the treasury was exhausted in attempting to give Hungary the appearance of civilisation before its foundations had been laid, and many other things of much more vital importance than the above were neglected. One of the consequences is that Hungary is now like a human body supplied with arteries unfed by veins. It has railroads but no roads, and the dividends guaranteed on the former by the Government swallow up the enormous sum of 1,200,000*l.* annually from the State revenue. This onerous charge is far from being the only result of the absence of vicinal roads. Their want is an obstacle* in the way of the development of all the material resources of the country, much more serious and fatal than elsewhere, because the prosperity of Hungary is at present, and must for a long time continue to be dependent on the amount of raw material produced, transported, and exported, and because in many parts of it there are vast stoneless plains where it is impossible to drag even a pair of wheels through the mud into which the spring and autumn rains convert the rich loamy soil. Hence roads are of the utmost importance, and the Vienna Exhibition will have conferred no inconsiderable benefit on Hungary if, as I understand, machinery has there been purchased by the Government which will accelerate their construction and reduce their cost by 50 per cent. For besides its agricultural produce that country possesses great mineral treasures which are at present almost worthless in consequence, to a great extent, of the want of easy means of communication.

There are five great beds of iron ore in Hungary. The first, in Transylvania, is of immense extent and the finest quality. The ore contains 50 per cent. of iron, and lies in large thick seams which can be worked without difficulty. In the same province, close at hand, were there roads, lies a coal basin 24 miles long and 2 miles broad, of cokeable coal of excellent quality, and there are forests which can supply 80,000 klafters (square fathoms) of wood fuel annually for a long period. All the elements, in short, of an extensive iron trade are there united, and yet the amount

* "The want of roads and the bad condition of those we have are the "chief causes of the backward state of our agriculture, commerce, and trade." —Extract from a speech of the Prime Minister of Hungary, from his place in Parliament, Nov. 8, 1873.

of iron ore extracted in 1871 was only 445,100 centners, and the amount of iron produced only 103,968 centners.

The second bed lies in the upper valleys of the rivers Temes and Karas, on the western slope of the Transylvanian mountains, is very extensive and of excellent quality. Fuel, both coal and wood, is abundant in the vicinity, but merely a small portion of this bed is worked, and the three smelting furnaces erected on it by the Austrian State Railway Company produced only 610,271 centners of iron in 1871.

The third extends over a large part of the Arad Comitat, but though wood fuel exists in the neighbourhood the coal found there is not cokeable and the amount of iron produced is insignificant.

The fourth bed lies on the north-eastern frontier of Hungary towards Galicia, and is not continuous but rather a succession of seams of ore cropping up sporadically at several places. It is not of very good quality and as the supply of wood fuel in the district will soon be exhausted it is probable that the smelting furnaces there will ere long have to stop work.

The fifth bed situated near Gran is perhaps the most important of all and at present the most productive. Though inferior in extent to the Transylvanian bed, its ore is of the finest quality and it can easily be supplied with large quantities of wood fuel from the neighbouring forests and, in default of Hungarian made coke, can obtain that material at a moderate rate by means of the railway lines which connect it with the Moravian and Silesian coal mines. But even under these favourable circumstances the produce of iron in 1871 was only 1,289,313 centners, and the total produce of Hungary during that year did not amount to more than 2,658,008 centners, an insignificant quantity as compared with the extent and richness of the above-mentioned beds of ore. Want of capital is no doubt one of the reasons why the iron trade of Hungary is so unproductive; but want of roads is another and perhaps the principal one. Otherwise, the railway companies would assuredly find it to their advantage to manufacture their own rails on the spot instead of importing them all, as at present, from abroad.

There can indeed be little doubt that, were the beds of ore in the country properly worked, Austria-Hungary would not only be able to supply her home requirements, but would become a large exporter of iron and find a ready market for her surplus produce in the neighbouring provinces of Turkey where, as civilisation progresses eastwards, there

will for long be a great and constant demand for iron for the construction of railways, bridges, &c. In this respect the Transylvanian bed would seem to be admirably situated.

The coal beds of Hungary, scattered about in various places throughout the country, are as rich and extensive as its beds of ore. But want of roads is again one of the chief causes of their remaining unproductive and hence it is that large quantities of coal and coke are annually imported into the country, as much as 2,868,332 centners in 1870 and that Prussian coal is burnt at Buda-Pesth.

Hungary is still a purely agricultural country and the agricultural machine hall of the exhibition was naturally the chief object of the visits of most Hungarians. The English manufacturers are held in highest repute as they have studied the wants of the country and adapted their machines to its requirements. Considerable orders were consequently given for all sorts of English machines, and the more they are known the greater will be the demand for them, as the price of manual labour is excessively high (more than double of what it is in Bohemia and most of the Cisleithanian provinces),* and insufficient for the cultivation of the soil, and because the produce of the latter, especially wheat, tobacco, pulse, &c., will always form the principal items of national wealth.

There is, however, no reason why Hungary should not itself manufacture a considerable number of fabrics (besides those of iron already alluded to), at any rate in sufficient quantities for its own consumption, and it is probable that the Vienna Exhibition will give an impulse to the, as yet, embryonic manufacturing enterprise of the country.

Within the last few years a considerable number of steam corn mills have been erected at Buda-Pesth and elsewhere, and there are now 480 in the country. Many of them however appear to be in no very prosperous condition. Their proprietors find it difficult to compete with their rivals, 18,000 water and wind mills, and attribute their want of success, probably with justice, to the dearness of coal, and the absence of easy means of transport.

In other respects the application of steam power to manufacturing purposes is quite in its infancy. Spinning and weaving are almost exclusively carried on by hand, as household industries, and manufacturing establishments under the general acceptation of the term are at present

* In Bohemia the ordinary rate of wages for day labourers is one shilling. In Hungary it ranges from two to four shillings.

hardly known, the principal factories being a wool combing factory at Buda-Pesth which employs 448 workmen, five cotton spinning factories with a total of 120 workmen, and three or four sail cloth and sack cloth factories. Their produce is, it need hardly be said, insignificant, and Hungary has to purchase all the entire fabrics consumed in the country from Cisleithania or import them from abroad. As, however, large quantities of hemp, flax, and wool, are produced, the time will probably come when instead of exporting the raw material, it will be found a lucrative speculation to manufacture it at home.

In the foregoing remarks I have attempted to adduce a few of the reasons which have led me to think that the idea of holding a Universal Exhibition at Vienna was not a mistake, and that the realisation of that idea has not been a failure, as well as to give same instances of the manner in which it may be expected to affect the material progress of the empire. I must add that, though International Exhibitions of only one or two branches of industry, such as those now annually held in London, are probably more advantageous in countries of advanced civilisation they would hardly attract the attention of the masses, where millions are almost entirely ignorant of its rudiments. In the wide spread provinces of Austria-Hungary few indeed would think of visiting them, and any advantage they might confer would be limited to a comparatively small class. What was wanted in that country was an Exhibition which would be such a centre of attraction that all classes and ranks would contribute to and visit it. This has been done, and though the empire has this year been sorely visited by a pestilence which has carried off 150,000 persons, by a financial crisis which has temporarily crippled its creative power, and by such a deficiency in the produce of the harvest that in several districts great misery, if not famine, must be looked for, it may congratulate itself on the position occupied by its manufactures and industry at Vienna, and may confidently hope that this Exhibition, besides exercising a beneficial influence on the material and intellectual life of its inhabitants, desseminating civilisation amongst them, giving an impulse to commerce and trade, and causing honest labour to be held in higher esteem, will also tend to smooth down the enmities and jealousies which still exist amongst its various nationalities, and unite them more closely under the beneficent rule of their common dynasty.

Buda-Pesth, AUG. H. MOUNSEY.
November 29, 1873.

THE REV. J. G. C. FUSSELL.

EDUCATIONAL APPLIANCES.

Report on Educational Appliances, by the Rev. J. G. C. Fussell, M.A., Her Majesty's Inspector of Schools.

Prefatory remarks.

It is not without serious misgivings that I have undertaken the task of attempting to describe the most noteworthy objects of education which were exhibited at the Vienna Universal Exhibition. For although I applied myself to my duties as a juror from the first meeting of the jury to the close of its final sitting, I left Vienna in the full belief that they were then at an end, and it was not until long after my return to London that I had any reason to suppose that this further duty would be required of me. Had it been otherwise I should have taken precautions which, in the absence of any apparent necessity for them, I unhappily failed to take. My daily notes were made with immediate reference to the necessities of the moment; in very many instances they assumed no permanent form; and as soon as the jury had arrived at its decisions respecting the objects to which they referred, I regarded them as having fulfilled their purpose, and was not always careful even to preserve them. Under these circumstances I venture to express a hope that the imperfections of my report may be treated with forbearance.

The first meeting of the jury for its regular business was held on Friday, the 20th of June; its labours were prolonged until the latest moment to which official regulations permitted them to extend, viz., till 6 o'clock on the afternoon of Thursday, the 31st of July.

Proceedings of the jury.

Our proceedings were directed by the official regulations of 15th February 1873. The classification upon which they were based was published on the 16th September 1871, and ran thus:—

Group XXVI.—Education, Teaching, and Instruction.

Preliminary Arrangements.	Sections for the Juries.
Education.—Exhibition of all the arrangements and contrivances for the better nursing, training, and rearing of children; their physical and	

Preliminary Arrangements.	Sections for the Juries.
mental development from the first days of their life up to school-time; their nourishment, cradles, nurseries, &c.; child gardens (kindergärten), child games and amusements, child gymnastics. Teaching. Exhibition of school-houses and school apparatus in models, drawings, and examples. Exhibition of means of instruction. The works and journals of instruction. History and statistics of a school, its organisation and laws. (1.) Elementary schools. This department will include apparatus for the instruction of the blind, deaf, dumb, and idiots. (2.) Middle schools, comprehending Gymnasien, "Realschulen," or schools wherein exact science and modern languages are taught. (3.) Professional and technical colleges. (4.) Universities. Instruction in the more limited sense; instruction of adults through literature, the public press, public libraries, and educational societies and associations for instruction.	1st section. Plans, organisation, means of instruction, and performance of national schools. 2nd section. Middle class schools. 3rd section. Technical colleges and universities. 4th section. Auxiliary means for the improvement of adults.

Constitution and scope of the various sections and sub-sections.

In accordance with these instructions, we at once proceeded to constitute our sections as follows:—

SECTION I.—Infant and other Primary Schools.

President.—Friedrich Dittes	Austria.
Vice-President.—de Thomas	France.
Reporter.—Rambert (Professor)	Switzerland.

SECTION II.—Secondary Instruction and Middle Schools.

President.—E. Levasseur	France.
Vice-President.—Julius Mosenthal	Austria.
Reporter.—Achtner	Austria.

SECTION III.—Special Schools—Upper Technical Schools and Higher University Instruction.

President.—Don Garcia Blanco	Spain.
Vice-President.—Alwin	Belgium.
Reporter.—Hyrtl	Austria.

SECTION IV.—Accessory Means of Education and of Instruction —Learned Societies. Societies for the spread of Instruction. Scientific Discoveries. Support and Moral Improvement of the Agricultural Classes and of Artisans.

President.—Baron Max de Kœnigswarter	France.
Vice-President.—Rambert (Professor) -	Switzerland.
Reporter.—de Leins - - - -	Germany.

Eventually it proved to be necessary, for fuller convenience of examination of the varied and extensive range of subjects included in sections I. and II., to subdivide those sections as follows:—

SECTION I.

1st	Sub-section.—	Exhibitions of the various Governments.
2nd	„	Kindergärten.
3rd	„	National and Lower Middle Class Schools: Models, Plans, Materials, &c.
4th	„	Teaching by means of visible objects, Pictures, Reading, Writing.
5th	„	History and Geography.
6th	„	Natural Science and Physics.
7th	„	Drawing and Caligraphy.
8th	„	Music and Singing.

SECTION II.

1st	Sub-section.—	Drawing and Plans.
2nd	„	Sciences and Gymnastics.
3rd	„	History, Geography, and Literary Instruction.

To each of these sub-sections was allotted a special share of the work before us. Every member of the jury remained, however, at liberty to take part in the proceedings of any and every other section or sub-section, as he might think proper.

My own official experience naturally led me to attach myself formally to Section I.; most of the time which my engagements there left at my disposal was devoted to the 3rd sub-section of Section II., where I had the advantage of working in conjunction with my colleague, M. Levasseur, the able president of that section. I owe it in great measure to M. Levasseur that I am able to present my remarks on geography in their present form.

Primary education.

It will be observed that on this, as on other similar occasions, primary education preferred the largest claim to the attention of the jury. From the very nature of the case this was so. An educational exhibition is (for the most part at least) an exhibition of appliances and instruments, rather than of accomplished results.

As we ascend from primary to higher education, many of the tests which at first were indispensable in enabling us to arrive at a just estimation of methods and systems, of the means which they employ, of the degrees of success which they are calculated to realize, and of their consequent claims to our approval,—many of these tests begin to fail us; their evidence becomes less and less conclusive.

To educate a child, you must begin by discovering some means of intercourse between yourself and him. External objects and impressions afford the earliest and, for a while, the only means of this intercourse.

The first concern, therefore, of education must always be with the senses and the perceptive powers, and whatever can facilitate her appeals to them is to be sought after and encouraged.

The plan and proportions of a schoolroom, its sanitary arrangements, its furniture, its books and apparatus, though never matters of indifference to the success of any teacher, are to the elementary teacher of almost vital importance, and the more elementary the teaching, the more distinctly is their importance felt.

Infant schools.

The most perfect exemplification of these principles is that which is afforded by every well constituted Infant school. Its arrangement and furniture are carefully designed for the child's comfort, and for such an amount of healthful amusement and exercise as will render body and mind fresh and vigorous for whatever occupation awaits them.

The lessons of the Kindergärten and other educational apparatus constitute a system of mental gymnastics which serve to quicken the senses and to arouse and develop the perceptions. They are instruments without which the best teacher is comparatively powerless, while their liberal and judicious employment opens a sure road to success. It is therefore evident that these and other kindred instruments of the more advanced primary schools may always be expected to occupy the most extensive space in every Educational Exhibition.

"The Infants' Pavilion."

The central committee of the Exhibition, completely alive to the important influences which educational associations are capable of exerting upon early childhood, had constructed what was termed "The Infants' Pavilion," designed especially for the exhibition of educational toys and games and other apparatus suitable for children of tender age. Unfortunately the arrangement of this building was delayed beyond the time expected, and some of its contents were so

much less instructive than others, that a selection of them might with advantage have been made.

The valuable system of Frœbel, however, the author of the "Kindergärten," was largely represented here, as well as in the separate exhibitions of different countries, especially those of the Austro-Hungarian kingdom, of Germany, Switzerland, and Sweden, countries which now regard these institutions as of essential importance, and as necessarily constituting the first step in the training of their teachers.

Importance of Frœbel's system;

Frœbel's system takes the child as he is, and encourages him to use his powers without overtasking them. Unconsciously, and by easy and well graduated advances, the child rapidly attains a surprising degree of manual dexterity, while at the same time he learns to observe and to describe peculiarities of appearance and shape in the various objects with which he is taught to amuse himself. Wooden spheres and cubes, and other geometrical forms exercise his powers of arrangement and construction; awakening in him a sense of order and of beauty, together with habits of well directed and persevering industry; clay-modelling arouses and gives scope to his inventive faculties; paper-folding, paper-pricking, weaving, slate drawing, and other interesting occupations impart delicacy of touch and accuracy of eye; the whole being varied by songs accompanied with action, and by appropriate gymnastic amusements which serve to develop the bodily powers, and to confer freedom and grace.

All this has sprung from Frœbel's labours in the modest school in Marienthal, where that single-minded and devoted educator thought out for himself and embodied the system which is, without doubt, destined to play so important a part in the education of both hemispheres. Since 1871 it has found rapidly increasing favour in America, while in several of the more advanced European countries, it has long more or less firmly taken root. Austria, in particular, by the ministerial decree of June 14, 1872, enforces its adoption in future as a necessary part of her educational training, and the practical effect of this decision may already be seen at the Normal training school for mistresses at Gratz.

its progress in general estimation.

The general adoption of a similar course is on all accounts to be desired. The benefits of the Kindergärten system are not confined to the period during which children remain under its immediate influence. Its immediate effects are indeed considerable, but these taken alone would afford a most imperfect measure of what has been accomplished. It educates the whole being, and so prepares the child for the easy and intelligent mastery of his future work. The School

Committee of the city of Boston, in the report which formed part of its contribution to the Exhibition at Vienna, speaks almost enthusiastically of the importance of the system from this point of view; of "the rapidity with which children "learn to read and write and cipher, after their faculties "have been developed and trained by the Kindergärten "work."

Those who have for some years past witnessed the operation of this system in the Infant school of the Home and Colonial Training Institution and elsewhere, will freely endorse this testimony.

Other Primary Schools.

The chief European nations contributed largely to this department of the exhibition. Great Britain alone stood all but wholly aloof; and though her absence was frequently referred to in language of friendly regret, it will readily be understood that my feelings under such circumstances were not of the most agreeable description. The United States of America were worthily represented. The contributions of British India possessed a peculiar interest, and those of some other countries were not undeserving of attention.

School buildings exhibited.

Austria, Sweden, and the United States of America exhibited schoolrooms of full size, completely furnished and fitted for immediate occupation. The educational buildings of Hungary, France, Bavaria, Saxony, Belgium, and Switzerland were chiefly represented by plans, drawings, and models, most remarkable among which was the model of the admirable establishment recently created by the city of Paris for issuing to its schools once a quarter,—or in urgent cases, more frequently,—everything that they require in the shape of educational furniture, books, apparatus, and materials, all of the most approved description, and in great part manufactured on the premises.

Plans, models, &c.

The Swedish schoolroom.

The Swedish schoolroom is calculated to accommodate 50 children; its dimensions are as follows:

Length	38 feet
Breadth	21 „
Mean height	14 „ (nearly)
Floor area	798 square feet, or at the rate of 15·96 feet for each child.
Cubical feet of internal space.	10,841 or at the rate of 216·82 for each child.

Each child has a separate "school-bench" comprising desk and seat in one.

There is in the desk an excellent feature which we also observed in those of the schools of Saxony, Hungary, and several other countries. It is so constructed that the sloping part, *i.e.* the front part, of its upper surface slides readily, but not too freely, upon supporting side frames grooved to receive projections attached to the sliding surface on its under side; the flat part or back of the desk, in which are the inkstand and the pen tray, being fixed and immoveable. This secures a proper position to the child when at work; a highly important point, too often overlooked by makers of school furniture. Having taken his seat he draws the slope of the desk forward to suit his convenience, and is thus enabled to write with ease and comfort, instead of having to lean forward with bent and contracted chest, in the manner so commonly witnessed in our English schools. Another useful contrivance is to be noticed in this Swedish "school-bench." The middle part of its floor (which is raised some three or four inches above the floor of the school itself) moves on hinges, and when lifted up falls back under the seat, out of the way of the scholar, leaving a shallow well in which legs of more than average length find convenient accommodation. A school house, such as I have described, could be produced at Stockholm at a cost of from 3,000 to 4,000 rix dollars, say from about 167*l.* to about 222*l.* In the country, where wood is to be obtained on the spot, the cost need not exceed from 1,000 to 2,000 rix dollars.

The furniture and school material is exceedingly well suited to its purpose. The teaching of geography is facilitated by the aid of good maps, and of a blackboard upon which the situations of the chief towns, &c., &c., are denoted by moveable coloured pegs inserted in holes prepared for their reception. The spelling and reading books, the books of arithmetic, geography, natural philosophy, gymnastics, and singing, are methodical and well written. There are unpretending but useful collections for instruction in mineralogy, botany, and zoology, and some well made instruments of a simple kind for teaching physical science. The pen holders were specially noticed; each one made of a piece of cork, and in size and shape closely resembling a very large cigar. The fingers are thus able to take good hold of it, while being light and slightly flexible, its use tends to promote a free and rapid style of penmanship. Everything in fact connected with this school appeared to have been thoughtfully designed and intelligently executed.

The American school house.

The dimensions of the American school house are:—

Length	-	-	- 33 feet
Breadth	-	-	- 26 „
Height	-	-	- 13½ „
Floor area	-	-	- 858 square feet, or at the rate of 17·87 per child.

Cubical feet of internal space 11,583, or at the rate of 241·31 per child.

The room being calculated to receive 48 children.

The benches are well finished and commodious, but less carefully graduated for children of various ages than were those of Sweden; the lighting also is not quite so well managed, there being windows on three sides. The arrangements and fittings are very good. Due provision is made for instruction in geography, zoology, botany, and mineralogy.

There was a very interesting model of the "Franklin school" in Washington. It is calculated to receive 64 children in a class, and the lighting and ventilation are well arranged. The model was said to have cost 1,000 dollars. There were also some striking photographs of other school buildings.

The estimated cost of the schools in Massachusets is 34,000,000 dollars; the cost of those of the city of Boston alone is said to have been 6,500,000 dollars.

The Austrian school house.

The dimensions of the Austrian model school house were these:—

Length	-	-	29 feet
Breadth	-	-	22 „ (nearly)
Height	-	-	11 „

It is calculated to receive 60 pupils.

The floor area, 624 square feet = 10·4 per scholar.

Cubical feet of internal space, 6,864 = 114 per scholar.

The school buildings of Vienna are excellent, and the schools are very liberally supported. Those also of Klagenfurt, Salzburg, Tyrol (Innsbruck), and of many parts of Bohemia and Silesia were well represented.

Plans of schools from Wirtemberg.

Plans of many fine schools were contributed by Wirtemberg, notably those of Weingarten, Eschenstrut and Schorzak, of Horkheim and Zainingen, Mushlangen Schalack, Wettingen, and Stuttgart. A large proportion of the school books exhibited by Wirtemberg were obtained from Northern Germany.

Bavaria.

The contribution of Bavaria was limited to a single school, the school of the Schwanthalen Gasse; it is one of

great importance, containing 28 classes, each arranged to receive 60 scholars.

Saxony exhibited an excellent collection of plans of school buildings, and her school furniture and apparatus received well merited attention. The schools are handsome and well arranged, the school benches and other fittings very convenient, and the books and apparatus good. Saxony.

From Prussia there was no exhibition of school buildings or of school books requiring special notice. Her display of maps and globes was, as usual, large and important, and will be noticed under the head of geography.

Belgium contributed largely in the way of maps and books, and of school apparatus. There was also an instructive display of plans of school buildings. Many of the Belgian contributions possessed great merit, and were generally interesting. Belgium.

Switzerland deserves especial notice. From the cantons of Argau, Bern, Zurich, Thurgau, St. Gall, Lucern, Appenzell, Bale, and from Schaffhausen came numerous exhibitions of school buildings, most of them well designed and well arranged. The school benches are of Dr. Fahner's type, and are well suited to their purpose. Switzerland was also a liberal contributor of apparatus for instruction in natural history, in horticulture, in physical science, and in other branches of education. Austria, Prussia, and France were also distinguished in this respect. The cost of much of the apparatus so exhibited, necessarily placed it beyond the reach of ordinary primary schools, but much remained that might reasonably be made available for their use. Switzerland.

France exhibited numerous well prepared prints of natural objects, of plants and of animals, drawn on a large scale; some of these were further illustrated by affixing to them specimens of the actual objects, taken from nature, as for example, specimens of minerals, or of different kinds of wood. Austria and Germany had a large and interesting display of prints of Natural History, printed sometimes on a white, sometimes on a black ground. Among the very best, however, was the collection of 100 prints exhibited by M. Masson, of Paris. They were specially designed for secondary instruction, and the price of the entire collection would prevent its general adoption in primary schools; a selection, however, of from 20 to 30 of these prints might be made, at a cost which, in many cases, might well be borne. It was matter for regret that this collection did not arrive until considerably after the proper time. Natural history.

Mr. Brendel of Breslau exhibited a valuable collection of plants in papier mâché; but this, too, was for the most part beyond the use of primary schools.

It appears that in Switzerland and in some parts of Austria, it is by no means uncommon to find teachers who train their scholars to a practical study of natural history. They teach them in their daily walks to collect grasses for herbariums; to form collections of the cereals and plants of the district; and of its rocks or minerals. There were in the Exhibition, and especially in the Austrian department, many such collections, some of which must have required for their formation no little time and care.

Physical science.

The contributions of apparatus for instruction in physical science were numerous and important, especially in Germany, France, and Austria. The attention of the jury was specially attracted by a humble but not ineffective apparatus constructed by the master of a French rural school for the instruction of his boys in the elements of electrical science. It was formed of the simplest and homeliest materials, among which we observed an old sardine case.

Model of the new school depôt of the city of Paris.

A special collection of educational objects was exhibited by the city of Paris. It included a highly interesting model of the depôt recently established for the supply of school furniture and material to the various primary schools throughout the arrondissements.

Origin of the institution.

In taking measures to repair the disasters which preceded and followed the signing of the treaty of peace with Prussia on the 26th February 1871, the extreme desirableness of such an organisation became apparent. The necessary steps were at once adopted, and under the direction of M. Gréard, Inspector General of Public Instruction and Director of Primary Education, the work has been, so far, happily accomplished.

The large scale of the model exhibited at Vienna enabled us to form a very clear general idea of the arrangement of the buildings and of the plan of operations carried out in them; and a personal visit which I have since been enabled to pay to the establishment, under the guidance of M. Gréard himself and of his able coadjutor M. Boyer, has more than confirmed the estimate I had already formed of its value.

Its present arrangement.

The principal building is traversed throughout its length by a central avenue, having on either side, at about half the height of the building, a broad gallery. Folding doors, sufficiently large to give passage to a loaded waggon, close

this avenue at each end. The galleries are chiefly used for storing desks, benches, tables, easels, blackboards, and other articles of school furniture. All supplies are delivered in the central avenue on the ground floor, and are thence readily hoisted to the galleries by means of an elevator. Other stores and workshops are conveniently grouped around this principal building.

Its difficulties at the outset.

Peculiar difficulties attended the creation of the establishment. Demands were made upon its producing powers while it was yet in course of construction. The havoc wrought during the siege and during the succeeding insurrection had been such that M. Gréard thankfully availed himself of whatever materials came first to hand, and the resources of the infant depôt were soon tasked to the uttermost for the adaptation of every description of damaged or disused school furniture; even benches from the canteens being pressed into the service. These energetic measures alone rendered it possible to make head against the difficulties of the moment, and to supply needful furniture and apparatus to the different classes as fast as they were ready to commence operations.

Its extensive usefulness.

The importance of the service thus performed is at once apparent from the official returns (L'Instruction Primaire à Paris, et dans Le Departement de La Seine, 1871–1872), which show that during the year ending 1st October 1872 additional accommodation was provided for nearly 20,000 children, distributed among 17 infant schools, 127 boys' schools, and 152 girls' schools,—involving the issue, during less than seven months, of 3,800 new tables, more than 1,200 tables repaired, 650 benches for playground use, 240 desks for teachers, and 137 for monitors, 575 chairs, 250 *school libraries*, 200 pairs of steps, 250 blackboards, 250 easels, and 325 clocks,—besides more than 1,500 wall maps, globes, and illustrations of the metrical system, 1,822 curtains made and fixed, and various small articles of furniture to the amount of nearly 9,000 francs. Since that period the completion of the establishment has been carefully prosecuted, and it is now effectually accomplishing the various objects for which it was created.

These are—

1. To issue once a quarter to all the primary schools of Paris such supplies of furniture, apparatus, books, and other school material as they may need.
2. To provide in urgent cases for their immediate wants and for accidental repairs.

3. To watch carefully over the quality of all goods and articles required for school use.
4. To adopt such improvements, whether of form or of construction, as experience may suggest.

For the accomplishments of these objects, the institution retains a moderate staff of skilled workmen, whose interest in their duties is very apparent.

Books, stationery, and large quantities of other articles are purchased; most of the wooden furniture is manufactured on the premises, and also some of the metal-work.

The whole establishment is carefully organised and administered, and its utility seems unquestionable.

The school libraries are for the use of teachers as well as scholars.

They comprise three classes of works—

(1.) Dictionaries; historical, geographical, and scientific.
(2.) Books of reference for school study.
(3.) Instructive and amusing works for general reading.

Each library consists of about 40 volumes, approved by the Prefect of the Department.

Hungary.

Hungary deserves far more than a passing notice.

Learning indeed has never been wanting among her educated classes. To them, Latin was for centuries, and until a comparatively recent period was still, a familiar language. Nor has she failed to recognise the importance of a more general diffusion of the benefits of education.

Her progress since 1867, however, has been astonishing. Perhaps no country has ever advanced so rapidly and at the same time so soundly.

History of public instruction in Hungary.

Public instruction in Hungary may be said to have taken its rise during the time of "Stephen the Holy," at the end of the 10th and the beginning of the 11th century, in the schools opened in the monasteries founded by this enlightened monarch. It spread more and more under the kings of the house of Arpad and following dynasties, while a still greater impetus was given to it in the time of King Matthias Hunyady. To its fuller development the Reformation also contributed; increasing by its influence the number of educational institutions already existing, and giving a useful impetus to its general progress.

The more systematic organisation, however, of public instruction in Hungary dates from the time of Maria Theresa. She appointed from the State Council a committee of education, which in the year 1776, in a scheme

entitled "Ratio Educationis totiusque rei literariæ per Reg-"num Hungariæ et Provincias eidem adnexas," organised national education in Hungary.

The administration of this system of instruction was not incorporated into the laws of the country, and was confined to Roman Catholic schools; the Protestants would have none of it, either under the rule of Maria Theresa or of her successors. Systematic instruction being, however, thus brought into operation, the Protestants proceeded to organise a system of education for themselves; and the Diet of 1790–91 having by the 26th article of the code secured to them, not only religious liberty, but also freedom of instruction, they set to work in earnest.

The system of education and instruction set out in the scheme "Ratio, &c." was entirely remodelled in the year 1806; but as it never became part of the general law of the land, two different views and systems of education and instruction,—the "Ratio Educationis" system, and the system of the Protestants,—grew up side by side. It was impossible to unite them, but in spite of this, education continued to spread. Their union was equally impossible during the period of repression which followed the insurrection of 1848.

Some idea of the progress more recently made, may be gathered from the following statistics:— Accomplished results of these concurrent systems prior to 1867.

There were in Hungary in the years

——	1857.	1865.
Primary schools	12,076	13,245
Children of school age	1,162,261	1,151,554
Children actually at school	828,500	985,403
Teachers	12,861	17,792
High schools (Gymnasien)	109	117
Scholars	17,564	25,639
Teachers	1,159	1,149
Commercial schools ("Real" schools)	12	39
Scholars	1,735	2,835
Teachers	107	161
Various ecclesiastical schools	40	40
Scholars in the same	1,509	1,682
Teachers of theology	177	214

In the 16 different law schools in the year 1864 there were—

Students	1,100
Professors	80

In the Royal Hungarian University in Pesth there were in 1864—

Students	1,901
Professors	70

In the Polytechnic School in Ofen in 1864—

Students	270
Professors	28

Such was the position of the systems of instruction when in 1867 constitutional life was restored to Hungary.

New and comprehensive legislation then carried out.

One of the first steps of the new legislature was to provide a law of conciliation, which should embrace all parties, and extend over the whole country; thus securing the most important part of public instruction, viz., a law for the education of the people.

Universal compulsory education, with freedom both for the teacher and the taught, was by this law securely established. The supervision of the State was extended to every school, without distinction, while to each was allowed the right of self-government. The denominational schools and parish schools which already exercised it, were left undisturbed in this privilege, while it was extended to those who had not hitherto enjoyed it.

Primary education.

Parishes were empowered to found schools and to support them;—wherever religious denominations were either unwilling or unable to do this, the right and the duty were assigned to the parish. The State did not undertake either to erect or to support schools, except where the parish was itself unable to establish them. It granted to private persons the right to establish private institutions, and allowed children under the supervision of their parents to be instructed privately in their own homes, on the sole condition, that such scholars should be bound to be examined every year in some public school. The character of the school buildings, moreover, was prescribed, and the size of the schoolrooms fixed, and it was required that a schoolroom should be provided for every 60 scholars, and that no teacher should instruct more than 80 scholars.

It was decreed that every school should be provided with the necessary requisites and apparatus, and that poor children should receive gratuitous instruction. It was ordered that the whole cost of instruction should be borne by those denominationalists who desired to exercise the right of undivided control over their schools; in other cases the burden was to fall upon the parish, which was required to establish a sustentation fund, and to increase the same when necessary. Those parishes which had not the means of properly supporting their schools, were to be helped by the State.

Every child between the ages of 6 and 12 was obliged by law to attend the day school; from 12 to 15 they were to attend the evening schools established for "further education."

Tinted Map

SHEWING THE PERCENTAGE OF CHILDREN OF SCHOOL AGE ACTUALLY ATTENDING THE SCHOOLS IN EACH SCHOOL DISTRICT OF

HUNGARY,

DURING THE YEAR 1871.

N.B. The tints correspond with those shewn in the Tables at the sides of the Map, and in the percentage scale at foot.

The subjects of instruction,—even the general methods on which it should be conducted,—the number of hours of instruction per week (which was not to exceed from 20 to 25 hours),—the time during which the school was to be open (8 months in the country, 9 months in the town)—were all duly defined.

It was provided that in addition to the elementary schools, middle or higher schools for the people should be established, to meet the wants of those desirous of extending their education. The quality of these was also prescribed.

It was provided that 20 Seminaries (normal schools) for the training of government masters and mistresses should be at once established, in addition to the denominational schools of this class already existing. The conduct and management of these normal schools was entrusted to the parishes and counties, each denominational training school remaining under the management of its own denominational body.

The parish was required to elect a "*school board*" consisting of at least nine members. Each county was to elect a *school council* consisting of not less than 14 nor more than 34 members, superior in authority to the school boards. It was to assume the general direction of educational affairs, to offer suggestions where necessary, and to report to the county authorities, who in turn would furnish their report to the Minister of public instruction.

One of the most important arrangements of this law respecting primary education, is that the State extends its immediate supervision over the schools of every class. For this purpose, the whole country was divided into school districts, and for every school district one or two school inspectors were appointed, whose duty it is to inspect the schools at least *once* every year, and to see that every requirement of the law is carried out. They also preside in the school council, and have charge of the management of the training schools. The law provides for the advancement of the education of the teachers, for the security of their situations, for the maintenance of their privileges; it fixes the minimum rate of salary, which, in the case of parochial school teachers was not to be less than 300 gulden (30*l.*); and makes provision for the establishment of a pension fund, as well for the teachers themselves, as for the support of their widows and orphans.

More advanced education.

The above provision being made for primary instruction, measures were proposed in the Diet for a similar organisation of middle class schools and institutions for teaching the higher branches of science; and pending the time that

might elapse until such measures should become law, provisional arrangements were entered into, and the necessary preparations made by the authorities in view of that event.

Results. On the basis of the primary education laws, as it at present stands, and the provisional arrangements for middle and higher schools, the following results are already apparent:—

Primary schools.

Primary Schools.

—	1869.	1871.
Children of school age - -	2,304,887	2,206,187
Children actually at school - -	1,093,071	1,233,500
Schools - - - -	13,646	14,550
Teachers - - - -	17,769	19,297

In 1871 there were 13,535 schools provided with apparatus, &c. Up to the year 1871, 295 primary schools were in receipt of help from the State, to the amount of 369,199 gulden. 2,314 teachers received from the State, without distinction of religion, subsidies to the amount of 149,730 gulden. There are at present existing 20 State training schools and 40 denominational ones, the former being continually in course of extension. At the close of the year 1871, there were, in the State and denominational training schools together, 1,786 students in 119 classes under the direction of 368 professors. This number has at the present time greatly increased, and there are now in the State training schools nearly 1,000 students who are provided with board and education at Government expense. For existing teachers supplementary teaching courses, of which without distinction of religious profession more than 10,000 teachers availed themselves, were opened simultaneously at from 35 to 40 different places. For the furtherance of popular education the Minister sanctions and orders the compilation of school books, and the preparation of school apparatus for the use of Seminaries and schools. Supplies of these to the amount of more than 200,000 florins have been issued to the elementary schools without distinction of creed. In addition to the above described measures for the primary education of the children, provision was also made for the instruction of adults by the teachers of the primary schools in consideration of an additional government allowance. During the years 1870–73, 55,000 persons took advantage of this instruction, all of whom learned to read, write, and cipher.

Under the constitution which came into operation in 1867 the middle and upper schools show the following comparative states of progress:—

Middle schools.

Gymnasien.	1867.	1871.
Scholars	33,908	30,992
Teachers	1,442	1,624
Upper Gymnasien	—	99
Lower Gymnasien	—	47
"Real" Schools.		
Scholars	2,661	5,472
Teachers	191	267
Upper "Real" schools	—	11
Lower "Real" schools	—	17

Many of these middle schools were erected or enlarged at the expense of the State, and the greater part provided with school apparatus. It is especially worthy of notice, that during this period, a training school for the education of teachers for middle schools was established by the University of Pesth.

Higher schools.

Higher Educational Establishments.	1867.	1871.
(*a.*)		
Theological seminaries	41	41
Scholars	1,682	1,660
Professors	214	231
(*b.*)		
Schools of law	15	15
Students	1,676	2,074
Professors	83	102
(*c.*)		
Universities	1	2
Students	2,116	2,375
Professors	91	149
(*d.*)		
Polytechnic schools	1	1
Students	250	451
Professors	27	42

Besides the provision thus made for *direct instruction* Hungary has of late years largely developed and added to various public institutions for the advancement of national culture.

General national culture.

During the years 1869–71, no less a sum than 239,102 fl. was expended upon the National Museum. A national model drawing school and seminary for teachers of drawing has been founded; the National Conservatorium has received liberal support; stipends have been granted in aid of the travelling expenses and the instruction of musical professors and students; and, finally, in the early part of 1873 it was determined to erect a national academy of music to be opened in the course of the year. In addition to all this, considerable sums have been devoted to the preservation and collection of historical works of art.

The reality and extent of the interest taken by Hungary in the elevation and development of her national culture may be to a great extent measured by the rapid yearly increase of the State budget voted by the Diet. The vote for public instruction, which in 1869 amounted to 1,367,400 fl., had increased in 1873 to no less a sum than 4,632,628 fl.

Chemical laboratory of the University of Pesth.

The Chemical Laboratory of the University of Pesth deserves special attention not only as being the latest development of those institutions for the advancement of chemical science, which have of late years been established in Germany and Austria; but also on account of the interest taken in it by the jurors on their visit to Buda-Pest towards the close of their official labours.

Its history and description.

When, 12 years ago, Dr. C. von Thann was appointed to the chair of chemistry in the Royal Hungarian University. he found only the small provisional laboratory left by his predecessor; the lecture room afforded accommodation for only 90 students, whilst the 15 practising tables were scattered about the corridors. The new professor was able and popular, and as the number of students rapidly increased, it became evident that the erection of a new laboratory answering to the requirements of modern science could not long be deferred. The moment was however unfavourable for adding to the expenditure of the country, but the importance of such an institution in the growing development of the great mineral and agricultural resources of the country was fully recognised, and in 1867 the matter was definitively taken up, and the building begun.

The objects to be obtained in the new institution were, to furnish accommodation for 280 or 300 students at the lectures on experimental chemistry, while, at the same time, 70

Map

SHEWING THE DIFFERENT

GYMNASIEN, REALSCHULEN AND NORMAL TRAINING SCHOOLS

FOR

Male and Female Teachers,

EXISTING IN HUNGARY IN 1872.

practising students,—say 50 elementary, and 20 advanced,—might be engaged in the practical exercises of the laboratory, Further, that facilities should be afforded for the convenient prosecution of independent investigations in accordance with exact physical methods, for the production of preparations and the performance of chemical operations on a large scale;—that, in addition to the popular lectures for a more general auditory, separate lectures might be delivered to select classes by the tutors, &c.;—and finally, that the professor (and director) of the institute with his assistants and servants should be lodged in the building. Dr. von Thann had for several years previous to the commencement of the work visited all the principal laboratories of Germany, particularly (while the building was in progress) the newly erected ones at Leipzig, Bonn, and Berlin, in company with the architect, so that the experience and improvements of the most recent establishments might, as far as possible, be embodied in the new institution at Pesth, in which moreover the services of the architect of the Berlin laboratory were enlisted.

The building consists of a basement, ground floor, and one upper story, and has a frontage of about 190 feet, with a depth of 50 feet.

It is arranged in three main departments; in the centre the lecture group (comprising the entrance hall, lecture hall, and its appurtenances and basement rooms); on the left the working group (comprising a smaller lecture room, the large laboratory for beginners in the annexe, and 10 smaller laboratories, and rooms for special investigations); on the right the dwelling rooms.

From the main entrance a short flight of steps leads to a noble rectangular vestibule, adorned with medallions of noted chemists; hence a marble staircase, nine feet broad, separating into two flights, leads to the two entrances of the great lecture hall, about 12 feet above the floor of the vestibule; and from this landing the staircase then leads up on either hand to the upper story.

In the *lecture hall* the two entrances open upon the last and highest row of seats; these are traversed by two descending gangways, corresponding to the two entrance doors, and contain 290 convenient numbered places. The benches are so placed that their upper edges lie in a parabolic curve rising more steeply towards the rear, an arrangement more advantageous both for hearing and seeing, than if the benches rose in a straight line. The hall is lighted on either side by five lofty windows, which descend from the

ceiling to the height of the last row of seats, and diffuse an equable light throughout; they are provided with stout venetian roller-shutters of very simple construction, by which the hall may be readily darkened when required.

The *experiment table*, which stands at the east end, is provided with a large quicksilver trough and a glass trough for gas experiments. In the centre part of the table are two openings in air-tight connexion, with descending earthenware pipes continued under the floor to the back wall, through which they are carried up above the roof of the hall. On lighting gas jets placed within these pipes a strong draught is established through the latter, carrying off all objectionable vapours evolved in the course of experiments, which are for this purpose conducted in glass cylinders placed above the openings. In the body of the table are bestowed the larger apparatus for the production of carbonic acid and hydrogen, together with a number of small quicksilver gasholders so that the more important gases for the experiments may be always at hand. The cock of the large oxygen gasholders in the basement (the water supply and pressure valve of which may be controlled from the lecture hall) lies upon the table, which is also amply provided with all the necessary gas and water taps. In front of the table stands a small stone pillar, on which are placed instruments requiring very nice adjustment, in particular those used in projection experiments. On the upper part of the wall, behind the table, are painted in clearly legible characters the most important constants,—as atomic and molecular weights, chemical co-efficients of energy, &c., &c. Below these, in the centre of the wall, is a large recess, with a smaller niche on either side of it, each ventilated by an earthenware pipe. To right and left of the niches are placed two cases for re-agents. The large recess is generally closed by a vertically sliding blackboard, on raising which the recess is so well lighted (the back being of glass) by the three large windows of the preparing room behind, that objects placed in it are seen in strong relief. Moreover, by means of a heliostat placed in the opposite window recess of the preparing room, direct sunlight can be thrown upon the experiment table, while it is also contrived that, by means of the solar or oxy-hydrogenic miscroscope, objects may be projected on a transparent surface placed in front of the recess in the lecture hall. In a similar manner, by means of a combination of the heliostat with the Duboscque electric lamp, the spectra of the different metals may be projected side by side with the solar spectrum, and thus the direct

comparison of the objective spectra made possible for a large audience. The electric light is served by a powerful battery in the basement.

The preparing room in rear of the lecture hall opens on the one side into a mechanical workshop, on the other into a small consulting room for the Professor. In the basement below (accessible also from the staircase) are two large store rooms for glass and porcelain instruments, and one for materials, from which the practising students may provide themselves at appointed times with what they require. Here also is a roomy ice cellar, adjoining an apartment where operations requiring a low temperature may be performed.

From the main entrance upon the ground floor, a wide corridor on the left leads to the *laboratory for beginners* (in an annexe),—a large room lighted by five windows on each of the long sides, and affording accommodation for no fewer than 50 operators practising at once.

In his former provisional laboratory the Professor had instituted special lectures to the practising students on the conduct of experiments, with, however, but small success, owing to the difficulty of carrying away accurate impressions of successive experiments without an opportunity of at once repeating them. In view, therefore, of the importance of these practical exercises, he resolved to provide for a special course of lectures to beginners, where each might have the opportunity of reproducing the most important experiments and observations during the lecture itself. For this purpose the laboratory has been specially arranged. The work-tables are constructed without the usual re-agent stands; the re-agents being deposited in small cases, closed with light roller-shutters fitted on at the side and above the tables so as not to impede the view across the tables of the lecturer's operating table. The latter stands in a recess in the middle of the south wall, well lighted by two windows, and raised one foot above the floor. Here the experiments are performed in view of all the students, and their attention is directed to all the various artifices so necessary to the success of any experiment. The students are thus able to repeat immediately the experiments exhibited to them, and without overtasking the memory, to make rapid and sure progress. The work-tables in the laboratory are arranged partly down the centre of the room, two and two, against brickwork pillars (through which the pipes of the ventilating niches are carried up), and partly in the window niches. The centre tables allow of four operators working at each,

and two operators at each window recess; so that at the ten centre tables and five windows fifty students can practise simultaneously, each having separate locked drawers and cases for his instruments and re-agents.

For the purpose of passing off the deleterious vapours evolved in the operations, Hoffman's evaporating niches have been adopted in the different laboratories. A small hearth, floored with a slab of slate and lined with white glazed tiles, is thoroughly ventilated by means of an earthenware pipe. It is furnished in front with a vertically sliding glass panel, the lower third of which turns upon a horizontal axis, and may be fixed at any inclination. This flap forms when open a small apron, under which such operations as the filtering, evaporating, &c. of odorous fluids may be conveniently carried on in front of the niche proper, without annoyance to the operator. When the panel is open the air streams into these niches from the room itself; when closed, the air is drawn up from the basement, and the basement floor thereby ventilated.

The disposition of these niches is an improvement upon that adopted in laboratories. The floor of the niche is in the same plane with the surface of the table, and, *in fact, forms part of it*, experience having shown that when the niches are even slightly removed from the tables, the inconvenience is often sufficient to deter the operators from using them, even where such disuse is prejudicial to the air of the room. Under the present arrangement the beginners obtain the gas supply for their Bunsen lamps solely from the niches, and thus for convenience sake are driven to perform all operations requiring application of heat, either within the niche or immediately in front of it.

Besides these smaller niches, there are also several larger ones, constructed expressly for blow-pipe analysis and for evaporating operations on a larger scale. These are provided both with sand and steam baths connected with the boilers of the steam-heating apparatus, provision being also made for securing a stronger draught.

An additional room, suitably arranged and ventilated, is specially designed for working with sulphuretted hydrogen.

For the advanced students, who are chiefly occupied with more complicated methods and their applications, smaller laboratories were deemed more suitable than one large common room. Their occupations occupy several hours, and often whole days, and involve the setting up of a complicated apparatus, which it would be hazardous to leave standing in a common room, and inconvenient to dismount and

put together again. In the smaller laboratories, where only from four to six work together, there is less risk of damage, and the doors may be locked and the apparatus left in position during the absence of the operator. A small niche is provided for every two students, with a large working niche lighted from the back; and besides the smaller tables, a large common experiment table, with locked drawers and cupboard. To every two laboratories, moreover, is attached a weighing room, and a small common room for the finer kinds of fire work, provided with combustion niches and other necessary apparatus. There are also four special rooms, one for spectrum analysis and experiments in electrolysis; another for gas analysis; a third for thermo-chemical inquiries; and a fourth for work requiring high temperatures, vapour-tight conditions, the heating of closed tubes, &c. For observations on the chemical nature of sunlight, and for comparison of spectra of the heavenly bodies, a table is fixed upon a platform on the highest part of the building above the roof of the central pavilion.

The basement rooms are 10 feet high, and well lighted with windows. In one of them, set apart for the distillation of inflammable liquids, there are two iron stills (in connexion with the large boiler) with reservoirs of different material; no fire is ever allowed here. In another (the smelting room) are fitted the smelting furnaces, the copper boiler for the production of distilled water, and a small still. A larger room is devoted to operations on a large scale, and contains a long experiment table and several small ones, a *Seftström* stove, a pipe stove, an hydraulic press, &c.

The *ventilation* of the building is carefully provided for. Near the centre of the building is erected a chimney shaft, with an interior section of about a yard square, and rising from the basement some feet above the roof. An interior iron tube of about two feet diameter extends throughout the shaft, and receives the flue from the two boilers which supply the steam-heating apparatus in the basement. In warm weather, when the heating apparatus is not required, there is a special furnace, for the purpose of creating a draught in the central flue. In direct communication with the air shaft large channels extend beneath the building, and from these separate vertical channels are carried to the rooms above. In each room is placed a hot-water stove, rising about six feet from the floor, of a double cylinder of iron, with an internal capacity of from four to six cubic feet of water; beneath the stove opens the mouth of a tube, which is carried under the floor to the outer air; at either end of

this tube is a valve. Steam from the large boiler in the basement being conducted to the water in the stove, it is speedily raised to a high temperature, while the air of the room continues to circulate through the interior cylinder, till the whole has attained the desired uniform temperature. The hot water in the stove acts as a heat reservoir, and is sufficient to maintain the temperature of the room for some hours after the first heating. The room being thus heated, the outer air is admitted below the stove, and this rising through the inner cylinder, continues to supply the room with fresh warm air (either dry or moist, as required). The vertical canal before mentioned rising through the wall from the basement canal has two openings into the room, one near the ceiling, the other at the floor, each closed by an air-tight valve. The former is for the summer, the latter for the winter ventilation—(the one withdrawing the warmer air, the other the cooler stratum). When either of these valves is opened, the air of the room, being placed in communication with the main air shaft by means of the vertical and under-ground canals, is drawn down by the powerful draught of the shaft, caused by the heat of the central iron flue which passes off the smoke from the boiler furnaces (or the special summer furnace above mentioned). When the laboratory niches are in operation, a stronger draught through them can be secured by temporarily closing the ventilating valve; and when it is desired rapidly to clear any particular room of foul air, there is an arrangement by which the communication between certain parts of the building and the circulating canals may be cut off, so that the whole draught of the main shaft is brought to bear on the air passages which remain open.

In the great lecture hall,—which is only required to be periodically warmed,—in place of the hot-water stoves, a simple arrangement of convoluted steam pipe is adapted as the heating medium. The tubes are set in six groups in corners of the hall, in recesses masked by iron gratings. The principle of ventilation is novel. It is a common practice in such halls to admit warm air beneath the seats; whereby not only is an unpleasant excitement produced in the system, but the exhalations from the human body are carried direct into the room, either to be breathed by the auditory, or to be got rid of by a ventilation so energetic as to be disagreeable if not injurious.

Here, on the contrary, the vitiated air is taken away direct from the place where it is being corrupted, *i.e.* from the seats themselves, by the following simple arrangement:—

The floor beneath the seats is perforated with a number of small slits, and the empty space below the rows of benches being in communication with the main air-shaft by means of eight large vertical canals, the air of the lecture hall is continually being drawn off from the seats through the openings beneath them. In summer time the lecture hall can also be ventilated by six large openings in the roof, closed by open-work rosettes, which openings in winter are kept carefully closed. The advantages of such a system of warming by steam, in the case of a chemical laboratory, are manifold. From a hygienic point of view a method is to be preferred whereby the temperature can hardly exceed 100° centigrade, while the whole system may easily be attended to by a single man, and the danger of fire is reduced to a minimum. There is besides always at hand in all the laboratories a supply of steam to be applied in the various chemical operations.

The distinguishing features of the Pesth laboratory may be summarized as follows:—The whole building is laid out in such a manner as to group together the different parts in accordance with the purposes they are intended to serve. The whole establishment is capable of easy supervision, and is amply provided with light and air. Space has been economized as far as practicable. The building is most solidly constructed, and from its situation readily admits of indefinite extension. It possesses an excellent system of ventilation, both special and general, connected with a system of hot-water heating, which, in addition to its proper uses, admits of the steam being applied in the various chemical operations. The institution is also furnished with a perfect gas and water supply. Lastly, the arrangement for the conduct of the practical exercises, as above described, secures rapidity of progress with soundness and accuracy of instruction.

The cost of its construction and fittings has amounted to nearly 30,000*l.*, and this large sum is more than adequately represented in the magnitude of the edifice and the completeness of its equipment. This is the second great specifically scientific institution that has arisen in Hungary within a few years. No long time ago, the nation raised by voluntary contributions more than 100,000*l.* for the building of the new Palace of the Academy, and the increase of its endowment.*

When we consider the political vicissitudes of the past ten years, and the consequent strain upon the financial condition of Hungary, we cannot refuse to her our warmest admiration.

"A nation that is ready to make such sacrifices in the "advancement of science and of civilization, may not only "claim the possession of abundant national vitality, but also "the post to which her geographical position entitles her, to "head the march of the advancing army of modern culture "into the regions of eastern Europe."

Geography. Of all the subjects included in Group XXVI., geography occupied by far the most prominent position. It presented itself in other groups also; as, for example, in Group I ("Mining, &c."), in Group XII. ("Graphic Arts, &c."), in Group XVI. ("the Art of War"), and, on the proposal of the subsection specially entrusted with this part of our work, was investigated there also.

There were exhibited for our consideration—

(*a.*) Maps of various kinds.
(*b.*) Atlases.
(*c.*) Globes.
(*d.*) Plans in relief.

Maps. Of all these, Maps undoubtedly possess the widest educational interest. They can be made to embody and place before us all that is known about a country;—of its natural features, its political divisions, its population, its religious and social condition, its productions, and even its history. They minister to the wants, not only of the *savant*, but of the schoolboy.

Accuracy, which is the first and highest condition of their usefulness, is to be secured only by having recourse to the best models. These are to be found—

(1.) In the surveys of the various War Departments. (Our own "Ordnance Survey" is executed under the auspices of our War Department.)

(2.) In those Geological Maps which adopt the Government Survey as their basis.

(3.) In original maps contributed by travellers in regions hitherto wholly or partly unexplored.

In most civilized countries it is to the first of these sources that geography owes her deepest obligations.

Austria. Austria, the home of the Exhibition of 1873, possesses in her Institute of Military Geography an institution which for 50 years past has produced well-finished maps. Those of Northern Italy and of the Austro-Hungarian monarchy are well-known. She is at present publishing, on an enlarged scale (a scale of 300,000), Col. Scheda's map of

Central Europe, which attracted general notice at the Exhibition of 1867. It is being brought out in parts—180 sheets at 1 fr. 50 c. the pair—and is to be completed in 1876. A supplemental collection, which was not completed till the latter end of July, was exhibited by the Institute of Military Geography. It was especially interesting as being illustrative of the history and progress of Austrian topography. The progress that has taken place became strikingly apparent on comparing two maps of Bohemia, produced in 1726 and in 1777, with those of Upper Austria and Lombardy, in 1787 and 1795, and with a plan of the environs of Stadt Klauser, in Transylvania, designed in 1834. I may also mention a geological map of the Austro-Hungarian monarchy by Chevalier de Hauer-Hölder, and a new and improved edition of Baron de Czvernig's Ethnographical Chart. There were also some able and instructive agricultural maps of Küstenland (Trieste, &c.), of Styria, and of the Tyrol, and an atlas of the cultivation and products of Cis-Leithanie. These have been prepared under the direction of the Austrian Financial Department, and were exhibited in manuscript. Their publication seems highly desirable.

Hungary. Hungary has, under its new administration, a distinct Geographical Department, which exhibited some excellent original specimens. Among the most expressive were a hypsometric map, and a map of the cultivation of the most elevated district of the West Carpathians.

Switzerland. There were also good maps of Northern Switzerland, from the lake of Geneva to the lake of Constance, and of the more mountainous regions of the South; the former on a scale of 25,000, the latter on a scale of 50,000. The general colouring is happy, and the more precipitous mountains are effectively brought out.

Clear and highly expressive maps of the district of Lucerne, exhibited by Müllhaupt, of Berne, and Wurster, of Winterthur, on a scale of 25,000, "à la lumière oblique," were also remarkable as excellent specimens of that system. The well-known map of Switzerland, by General Dufour (scale of 100,000), and the completed portion of the official geological map which is based upon it, occupied conspicuous positions in the Central Rotunda.

Germany. Germany did not appear to have put forth her full strength; her contributions were nevertheless numerous and important.

Prussia. Among those of Prussia were duplicate sets of certain sheets of her admirable map, on a scale of 25,000, which is still in course of publication; one of these sets was coloured hypsometrically, the other geologically.

Bavaria. Bavaria sent a well-executed map of her own territories, on a scale of 50,000, and one of South Germany, on a scale of 250,000; also a hypsometric map of Bavaria, on the same scale, by the Topographical Department.

There was an imposing array of geological maps, most of them, however, arranged in Group I. ("Mining, &c."). A geological map of Upper Silesia, by Reimer, that of Prussia, on a scale of 100,000, by Berendt, the geological map of the Grand Duchy of Hesse, on a scale of 50,000, published by Justus Perthes, and that of the whole of Germany, by Dechen, were perhaps the most noticeable.

Russia. Russia exhibited one of her new maps of the region of the Caucasus, on a scale of 840,000; one of Kuldja in Upper Asia; plans of Tashkend and Samarcand; and a plan of the ancient channel of the Amou-Daria. She also exhibited a fine map of Finland, on a scale of 400,000 published by the Surveyor-General's Department, and several plans by the Central Statistical Department, relating to the theory and practice of agriculture.

Turkey. Turkey exhibited a large manuscript map of her European provinces, on a scale of 400,000, and an economic map of the Turkish Empire (also in manuscript) showing her forests, her agricultural productions, her various industries, &c., based upon information derived from the Consuls of the different provinces.

Egypt. From Egypt were contributed the geological maps of M. Figari Bey published some 12 years since.

America. From the southern continent of America a valuable manuscript map of Paraguay, a survey of the course of the Amazon by Costa Avezado, excellent maps of San Francisco by M. Liais, and of Brazil by Candido Mendès de Almeida, may be mentioned as deserving of notice.

North America contributed some well executed marine charts, a map of the Peninsula of San Francisco, several maps from the War Department, and a second edition of M. Marcou's manuscript map of the geology of the globe.

France. France exhibited many excellent maps. A medal of merit was awarded to the large geological map drawn, on a scale of 80,000, under the direction of MM. Élie de Beaumont and de Charcurtois.

The War Department exhibited a plan of Albertville, in Savoy, which for finished execution was equalled by few, and perhaps surpassed by none. It also contributed an interesting specimen sheet of a new map of Algeria, which is being executed in chromo-lithography. This system is undoubtedly capable of being made to yield important ad-

vantages, so long as the sheets are not allowed to exceed a moderate size. The new Federal map of Switzerland, to which I have already referred, some beautifully finished maps of Sumatra and other islands, by the Dutch Colonial Staff Department, and this new map of Algeria by the War Department of France are all excellent examples in point; they are all executed in small sheets.

A "carte muette" of France, on a scale of 800,000, printed in two colours, was remarkable for the precision of its relief.

The "George" process, by means of which corrections in the copper plates of the Staff Department are made as often as required, with the aid of a small graving tool and of the electric battery, was held to belong more properly to the jury of Group XII., and was accordingly left to be judged by them. The economy of the process is questioned, but advantage is claimed for it in the diminution of risk of injury to the plates, and on other grounds. The "George" process.

In the matter of atlases, France—although, when viewed in comparison with other nations, she no longer maintains her former supremacy—numbered among her exhibitors at Vienna, one whose high claim to distinction was indisputable. For delicacy of finish, for harmony of colouring, and for accuracy in the minutest details, the work of M. Vivien de St. Martin, now in course of publication by Messrs. Hachette, was probably second to none. Atlases. France.

The atlases of M. Lechevalier and of M. Lanée, "Le Globe Illustré" by M. Cortambert, an atlas edited by the Christian Brothers, and a small atlas of France and her colonies by our colleague, M. Levasseur, are justly entitled to commendation.

From America we had Colton's large atlas—complete, but somewhat coarsely coloured. Those of Guyot, Warren, Steinwehr, and Cornell were all recompensed by the jury. They are published in volumes, with an explanatory text, and arranged for schools in different stages of advancement, from the primary school upwards. To M. Guyot, the originator of this useful system, the jury awarded a medal of merit. America.

Austria also furnished her contingent. Her chief work was the well known atlas edited by M. Artaria, of Vienna; accurate, but open to the objection that it is overloaded with details. The school atlases edited by the Austrian Education Department, containing maps of the different provinces, a cheap small atlas by Steinhauser, sold for 60 kreutzers, and the good but more costly atlas of Kozenn, as well as others procured from Germany, are extensively used in the schools of Austria. Austria.

Germany. Germany is at present unrivalled for her supply of school material in connexion with geography. The triumphal pyramid of maps and globes which occupied all the central space in her educational exhibition, and reached from the floor to the roof, was a practical assertion of her superiority in this respect.

Lange's cheap and well-known small atlas, edited by Brockhaus of Leipsig, his atlas of Saxony, which costs three thalers, and his general atlas in 30 sheets, executed in chromolithography, were all well-deserving of notice.

The same remark applies with still greater force to the atlases of the Geographical Institute of Weimar, and to Kiepert's atlases edited by M. Reimer of Berlin.

Distinguished, however, above all competitors was M. Justus Perthes of Gotha. It would be tedious to enumerate his productions. I may mention, however, the historical atlases of Spruner and of Menke, Sydow's well-known and important works, and especially Stieler's grand atlas, a fresh edition of which is in preparation. The excellence of the productions of M. Justus Perthes secure for them an extensive sale, more than 8,000 copies it is said to each edition, and he is thus enabled to afford the expense of new editions as often as fresh geographical discoveries seem to call for them.

On the special recommendation of the jury, the unusual distinction of a "Grand Diploma of Honour" was awarded to M. Justus Perthes.

Switzerland. The atlases of Switzerland, though comparatively few in number, received well merited approbation.

WALL MAPS. Switzerland. For the wall-maps of her own territories—and to these her efforts are chiefly confined—she has a useful model in the maps of her Staff Department. Her cantonal maps, especially, were numerous; they are extensively used in her schools.

France. Hitherto France does not appear to have been sufficiently alive to the importance of superior wall maps. The map of France by M. Cortambert, edited by M. Andriveau Goujon, was the only French wall map honourably distinguished by the jury. Others, however, are in a forward state. One by M. Pigeonneau is being edited by M. Belin; Messrs. Hachette have nearly ready a wall map of France by Messrs. Meissas and Michelot; and since the jury terminated their labours, M. Delagrave has brought out a wall map of France on a scale of 1,000,000, drawn by M. Hansen, under the direction of M. Levasseur.

Germany. Here again Germany was able to defy competition. Her exhibition of wall maps was even more remarkable than that

of her atlases. Without pretending to give anything approaching to an exhaustive list, I cannot do wrong in mentioning the following. From the Institute of Weimar, Ancient Greece and Italy; the Roman Empire by Kiepert, a masterly production; the map of Saxony by Delitsch, under the auspices of the Department of Public Instruction; and a whole host of works by Kiepert, Raaz, Möhl, Sydow, Peterman, Wagner, Dolezal, Berghaus, and others, published for the most part by Reimer of Berlin, Kellner of Weimar, and Justus Perthes, of Gotha.

Hungary. Under the sanction of the Educational Department of Hungary, and at the instance of our colleague, M. Paul Gönzcy, excellent maps of Europe,—of the Austro-Hungarian monarchy,—and of the Crown lands of Hungary by Dolezal and Berghaus have been edited in the Hungarian language; Stieler's small map and Schotte's globe have been similarly adapted; while no fewer, it is said, than 15,000 copies of a small school map of Hungary, prepared under the same auspices by Justus Perthes, have been distributed by the Department among the schools of the country.

Austria. Austria has recourse to German publishers for many of the wall maps she requires, but she has excellent specimens of her own. Europe, Central Europe, and the Map of the World, prepared by Colonel Scheda for the Educational Department of Austria, are marked by the clearness and accuracy which are characteristic of that author. A hypsometric map of Austria, edited by the "Schulbucher Verlag," Steinhauser's map of Lower Austria, maps of Bohemia and Styria, by Kosenn, and several other wall maps of the Austrian provinces were favourably noticed.

Belgium. Two maps exhibited in the Belgian Department,—one of Belgium, the other of Europe,—by "le Frère Alexis Gochet," were worthy of notice. They are chiefly physical, and represent the principal features of climate, cultivation, and hypsometrie. They are strikingly, rather than harmoniously, coloured, with the professed object of arresting the attention and impressing themselves upon the recollection of children in primary schools, for whose use they are specially designed. Without in any degree disparaging the undoubted merits of these maps, one may be permitted to prefer and to have faith in a more artistic style of treatment. A medal of merit was awarded to Frère Alexis Gochet for his maps, which are now extensively adopted by the schools of the Christian Brothers in France.

Sweden. There were some excellent wall maps from Sweden, especially M. Mentzer's "carte muette" of the Scandinavian

Peninsula, on a scale of 1,250,000; and a manuscript map of Scandinavia and Finland, by M. Backhoff, on a scale of 1,000,000.

United States of America.

In the United States of America, M. Guyot again outstripped his competitors. His wall maps are skilfully executed, and the physical features of the countries represented are well and effectively brought out. A medal of progress was awarded to M. Guyot.

Relief Maps. Germany.

In her exhibition of maps in relief, Germany was unequal to herself. There was a good relief map of Saxony, by Vogel and Thieme, and one of portions of Upper Bavaria, by Professor Winkler of Munich. Schotte's relief maps, especially his Europe, are less successful; and a comparison between a huge planisphere in relief from M. Adler of Hamburg, and a well executed one from Switzerland, was beyond all doubt to the advantage of the latter.

Austria.

Austria, France, and Switzerland were the most successful. The collection of the Institute of Military Geography of Austria contained valuable relief maps of various descriptions, and finished in various styles; among these was a map of Europe on a scale of 4,000,000, with the mountains on a scale of 200,000.

The Austrian supplemental collection, to which I have already referred, contained numerous examples; Streffleur's Alpine Passes, a carefully executed plan in relief of Mt. Priel, in Styria, by Lieutenant Wanka, with a corresponding map on the same scale; relief maps of the Schneeberg and of the Semmering; a large relief map of the Alps of the Salzburg Tyrol, by M. Franz Keil; and a relief plan of the Valley of the Eisach at Klausen, by Professor Guido Kutschereuter of the Military Academy, accompanied by a counter relief, in detached pieces, exactly corresponding to the depressions of the plan.

Hungary

Hungary was worthily represented by admirably executed plans in relief of the battle field of Grandson, of the Campagna at Rome, of the district of the Lower Danube, of Hungary and the Carpathian Mountains. To these must be added interesting plans of the bed of the Adriatic, near Fiume, and of some of the deepest parts of the bed of the Mediterranean.

France.

France exhibited some of the reliefs of the late M. Bardin, and among them his reliefs of Mont Blanc on a scale of 40,000. The great size and the high price of these noble productions must always be a bar to their general use, and it is matter for congratulation that Captain Peigne, Professor at the School of S. Cyr, has actually in hand a reduction of

them to a scale of 80,000. Two reliefs of humbler pretensions, though calculated for extensive usefulness,—one by M. Levasseur, published by M. Delagrave, the other by Frère Alexis Gochet, exhibited by the Institution of Christian Brothers,—are intended to be used, in primary and other schools, side by side with corresponding topographical maps on the same scale, with a view to accustoming children, from their first entrance upon the study of geography, to form clear and definite conceptions of elementary geographical truths.

Two other relief maps, edited by M. Belin, are worthy of notice: a small one of France by Messrs. Pigeonneau and Privet, and one of the environs of Paris, on a surface scale of 40,000, with the elevation exaggerated, on a scale of 20,000. M. Delagrave exhibited relief maps by Mdlle. Kleinhaus; two maps of France on different scales; maps of various departments, on scales of 500,000 or 200,000; and one of the Alps of Savoy and of the Isère on a scale of 500,000. They have the merit of great accuracy, and their price is not such as prohibits their use in primary schools.

Honourable mention was awarded to the Normal School of Angers for its contribution of a relief map of that department. A like reward was given to a teacher there, M. Molinier-Violte, for a relief map of Algeria. Credit is due to several Austrian teachers for useful contributions of a similar nature; and to M. Burgi, a Swiss teacher, for a well-executed relief map of that country, on a uniform scale of 250,000, vertical and horizontal.

A Swiss engineer, M. Hüni, exhibited a well-conceived series of reliefs of Zurich and its environs; the first coloured after nature—the second in plain white plaster, representing the bare surface of the country, as it would appear if stripped of houses and cultivation—and a third coloured hypsometrically. To these M. Hüni added two maps, one "à courbes," translating, so to speak, the third relief into map form; and the other with cross shading between the "courbes," thus leading up to the idea of a topographical map. There was also an ingenious attempt to illustrate the actual position of various strata beneath the surface of the earth by an arrangement of plates of glass appropriately coloured geologically. The tunnel through the Bâlese Jura and the Alps of Glarus were thus illustrated by M. Muhlberg and M. Heim respectively. Switzerland.

I must not conclude without mentioning a good relief map of Scandinavia by M. Mineur, of Stockholm; one of British India, by Mr. Griggs, after the familiar original by

Mr. Montgomery Martin; of Egypt and Lower Nubia, on a surface scale of 200,000, and vertical scale of 20,000, by Messrs. Streit and Walger; and a plan of Jerusalem and its neighbourhood, by Monsieur Illès. Two reliefs of an exceptional character—of Paris and its environs, on a scale of 5,000, by M. Bauerkeller, and of the Bosphorus, on a scale of 2,500—were interesting from the singular minuteness of their details, public buildings and even private houses being readily distinguishable.

The model of Paris was the labour of ten years, whilst that of the Bosphorus was executed in twelve months by a staff under the direction of Herr Seefelder. In this latter model, the scenery from the Golden Horn to the Black Sea was pourtrayed with striking accuracy. The architectural features of every mosque could be traced in detail. Stamboul, Pera, Scutari, were all reproduced with vivid distinctness, and the picturesque mass of walls and houses, pierced here and there by domes and minarets, and relieved by the verdure of trees and gardens, formed a scene which was at once charming and instructive.

Globes. The display of globes was chiefly confined to Germany, France, Austria, and the United States of America.

Germany. The Institute of Saxe-Weimar exhibited a large number, the work of Kiepert, Græf, and others; Reimer of Berlin, too, had globes by Kiepert, published in different languages; also globes in relief by Adami; Schotte had globes of both descriptions, plain and in relief.

France. Among those from France were globes exhibited by M. Bertanse, those of MM. Larochette and Bonnefont, published by M. Naud-Evrard, and those of M. Perigot by M. Delagrave; who also exhibited one by M. Levasseur, specially designed for elementary instruction in geography, and cosmography.

Austria. Austria seems to derive her inspiration, in great part at least, from Germany.

United States of America. The United States of America exhibited a considerable number of globes. Those of Schelder, of New Jersey, were especially clear and well executed, and were recompensed by the jury.

I have reserved for the close of my Report the exhibitions of the British Section—of the Indian Department—and of British colonies.

British exhibitors in Group XXVI. The number of British exhibitors in Group XXVI. proper, scarcely exceeded a score. A few objects in Group XII.

also came within the purview of the educational jury; but even including these, the whole number did not, I believe, amount to 30.

Small as was the list of the British Section, it included no fewer than six exhibitors of desks and seats for schools. The jury carefully examined all these, but awarded no distinction to any.

Mr. P. L. Simmonds exhibited a collection of 62 commercial varieties of cotton; a collection of 51 samples of laundry starches and edible meals and starches; also a collection shewing the economic and industrial uses of wastes and residues. Mr. Simmonds' book on "Waste Substances and "Undeveloped Products," which was exhibited with this last-named collection, has recently formed the subject of an interesting notice in the "Times" (March 16th, 1874).

The mosaic work exhibited by Major Du Cane is the produce of female convict labour at Woking and some other convict prisons; and has been largely employed in flooring the corridors of the South Kensington Museum. It was regarded with favour by the jury, not only as a revival of an ancient and long neglected art, but as a means of furnishing suitable employment to a special class of prisoners, without entering into competition with any established industry. A detailed account of the process of manufacture appeared in the official reports (Division II., Part IX.) of the London International Exhibition of 1871.

The three inventions which Mr. Adams exhibited in Vienna, and upon which the jury conferred a medal, have all of them an identical object, viz., the embodiment of abstract mathematical conceptions and relations in a visible and tangible form.

The first of them, the "Problem of Pythagoras," is an illustration of the famous proposition discovered by that philosopher and subsequently published by Euclid (I., 47), a proposition which forms the basis not merely of geometry, but of trigonometry, of statics, of astronomy, and in fact of almost every calculation in positive science. This illustration is effected by actual super-position in the manner which Euclid adopts, and each step of the process illustrates some proposition upon which the 47th is dependent.

The second is an instrument which Mr. Adams calls the "Mensurator." It illustrates most of the principal problems in Euclid and trigonometry, and many in analytical geometry, and performs, by virtue of its geometrical mechanism, many mathematical processes, such as, addition, subtraction, rule of

three, the solution of quadratics and simple binomial equations, &c.

The third is the "Cœlometer," which exhibits, in a concrete form, all the conceptions which are necessary for nautical astronomy, and the relations which exist between them.

These inventions were suggested to Mr. Adams by various difficulties which presented themselves to his own mind, during the progress of his education at school and at the university; and were primarily designed to simplify the study of elementary geometry.

In prosecution of this object it occurred to him—

(1.) To illustrate the propositions dependent upon superposition, by magnitudes actually imposed upon each other in the mode which Euclid describes.

(2.) To devise some instrument which should be capable of representing a triangle of any size or form with its corresponding altitude, and should be subject to all the laws by which a triangle is governed.

(3.) To devise an instrument which should illustrate physically the conceptions of celestial latitude and longitude and of right ascension and declination.

The method of presenting the true horizon soon afterwards suggested itself, and subsequently the corrections for dip, parallax, and refraction were added. By these means the whole theory of nautical astronomy becomes evident at a glance.

The mode of using these instruments will be easily seen from the handbook which accompanies each instrument, when read with the instrument itself before us. They are, one and all, intended not to supersede the present method of teaching geometry, but only to prepare for and illustrate it, and to raise in the mind of the student by mere force of observation, such conceptions of geometrical ideas and relations, as shall force him to the definitions and propositions of Euclid and of general geometry, in order to express his own ideas; or at least, shall enable him to recognise those ideas immediately they are expressed. For want of such help, many a one has for years gone on groping in the dark, never finding the use of the key which stands ready to his hands; and too often throwing it away in disgust, from mere ignorance of the treasures which a little dexterity would have unlocked.

The following is a list of the *successful* exhibitors in the British Section.

List of British Awards in Group XXVI., Great Britain and Ireland.

Exhibitor.	Exhibits.	Nature of Award.
Adams, W. Marsham	Educational instruments.	Medal of Merit.
Armitage, Dr. (British and Foreign Blind Association).	Educational works for the blind, consisting of relief maps, writing frame, plate for stereotyping, &c.	Medal of Progress.
Bartholomew, John	Map engraving and colour printing for atlases, educational and other purposes.	Honourable Mention.
Du Cane, Major -	Marble mosaic work by female prison convicts.	Medal of Merit.
Damon, Robert	Types and genera of recent mollusca, with catalogue.	Honourable Mention.
Havet, Alfred G. -	Educational works, French and German.	"
Johnstone, W. and A. K.	A school atlas; illustrations of human anatomy and physiology, &c.	Medal of Merit.
Rundell, J. B. -	A new system of shorthand, with adaptations to the English, French, German, and Italian languages.	Honourable Mention.
Sunday School Union.	Printed books, sheets, cards, &c. used in Sunday schools.	Medal of Merit.

The successful exhibitors in the Indian Department, and from the British colonies, are specified below.

India and the Colonies.

Exhibitor.	Exhibit.	Nature of Award.
Secretary of Local Committee of North West Provinces.	Specimens of school work and educational appliances.	Honourable Mention.
Secretary of Local Committee of Bombay.	" " "	"
Secretary of Local Committee of Bengal.	" " "	"
Secretary of Local Committee of Madras.	" " "	"
Secretary of Local Committee of Oude.	" " "	"
Secretary of Local Committee of the Punjab.	" " "	"
Indian Government -	Map of the Himalayas -	Medal of Merit.
" "	Geological maps of Salt Range, Bengal.	Honourable Mention.
Thomason Engineering College, Roorkee.	Engineering and other professional papers.	"

Exhibitor.	Exhibits.	Nature of Award.
Leitner, G. W., Dr. -	Promotion of education -	Grand Diploma of Honour.
	The Colonies.	
Buller, W. L., Dr. -	History of New Zealand birds, with illustrations.	Honourable Mention.
Daintree, Richard -	Geological maps of Queensland and New Zealand.	„
Lindsay, W. L., Dr. -	Flowers - - -	„

The specimens contributed by the Local Committees of Madras, Bengal, the North-west Provinces, and the Punjab were especially interesting, as serving to illustrate the character of the work accomplished by the native schools, and the appliances in use among them. They deservedly attained "Honourable Mention."

The Diploma of Honour awarded to Dr. Leitner may be considered indirectly as honourable to the Punjab Educational Department and to the Punjab University. Of both these he is a member, and many of the measures which he has advocated appear to have been first carried out in the Punjab with their aid. The Punjab Government may be congratulated on the fact that one of its servants has been instrumental in obtaining the highest educational honour gained at Vienna by Great Britain, by India, or by any other of our dependencies or colonies.

Dr. Leitner exhibited in several groups of the Vienna classification, but a distinct educational purpose was apparent in every one of his exhibits, even where an ethnographical, industrial, or antiquarian interest might seem to be paramount.

His collection in the educational group was unquestionably a most remarkable feature in the Exhibition. The tangible results of his active and persevering labours were directly represented by a large variety of objects, of which the following list was given:—

"1,000 Bactrian and other coins.
"184 Græco-Buddhistic and other sculptures.
"3,200 Himalayan butterflies and beetles (from Kulu, Dharmsala, &c.).
"25 rare manuscripts in Tibetan, Sanskrit, Turki, Arabic, Persian, Kashmiri, &c.
"177 ethnographical articles from Dardistan, Kafiristan, and various parts of central Asia.

" 197 industrial and other articles from central Asia, and northern India.
" A collection of Himalayan plants and minerals, between Kulu and Ghilghit.
" An educational collection."

Among the publications exhibited by Dr. Leitner at Vienna was his " Philosophical Introduction to Arabic Gram- " mar,"—" an attempt to account, by means of logic and " the laws of sound, combined with the history and manners " of the people, for some of the most complicated rules of " etymology and syntax." It is written in English, but has already been translated into Urdu, and it was stated that an Arabic translation is in course of publication. His treatise on the " races of Turkey and the state of their education, " with principal reference to Muhammadan education," not only shows us the various methods adopted in the education of the numerous races of the Turkish Empire, but seems calculated to suggest the course which should be taken in dealing with our own Muhammadan subjects. The condition and progress of Turkey, to whose ruler the vast majority of Indian Mussulmans look with deference, affords an illustration of the compatibility of western civilisation with rigid orthodoxy, and it might be well to point out to our Mussulman subjects that many of the measures of our Indian Government are identical with those of Turkey.

Dr. Leitner also calls attention to the Arabic and Turkish grammar and reading books used in Turkish schools, and to the manuscripts from Turkey, which were exhibited by him at Vienna, pointing out that while the former show a striking similarity to the Indian grammatical books, the MSS. are chiefly written in the " Rika " character—a character which is unlike either the " Sulus " of the Arabs, or the " Taaliq," used in India for the purposes of Persian and Urdu lithography. The " Diwâni " of the Turks is too ornate and complicated for ordinary use, but the official " Rika " would stand midway between the " Taaliq " and the " Shikasta," the running hand which is such a puzzle to Europeans.

Dr. Leitner's claim to distinction, as having taken part in the foundation of important educational institutions, was supported by the production of copies of official records and documents.

I must confine myself to some of those which are more immediately connected with his Indian career.

In 1864, the Punjab Government offered the principalship of the Lahore Government College (just founded) for public competition. Dr. Leitner applied for and obtained the ap-

pointment. He reached Lahore in November 1864, and there found a state of things which he at once set himself to remedy. He describes the government educational system as having little real hold on the people, who in sullen silence felt themselves to be disregarded, and their ancient civilisation despised. There was, indeed, we are told, a system of so-called English education, consisting chiefly of instruction in mathematics and random or fragmentary selections of more or less known authors. One of the courses contained portions of Mr. Dixon's "Life of Bacon," Prescott's "Essay on Cha- "teaubriand's Essay on Milton," Campbell's "Rhetoric," and Roger's "Italy," as a curriculum of English literature for advanced students; whilst in mental philosophy, Abercrombie; in history, a few notices of the history of the Jews, and of Rome, or Greece, were deemed sufficient. As regards the elementary schools, we learn from Dr. Leitner that some of the maps in use actually made the Sahara run through Spain, an error the peculiar character of which would seem to indicate that these maps may have been inaccurate reproductions of information originally derived from a Moorish or Saracenic source.

The educational despatch issued by the India Office in 1854, furnished the basis for Dr. Leitner's operations. Its main principle was "to pave the way for the abolition of "the Government Schools by means of voluntary organisa- "tions," but its provisions, such as, for instance, the Grant-in-Aid rules, were imperfectly known or understood by the natives, and decisive steps to carry it out were still to be taken.

Dr. Leitner began by endeavouring to arouse a spirit of self-reliance among the natives, especially among their natural leaders—the chiefs, the priests, and the wealthier merchants. He founded an association, the "Anjuman-i-Punjab," for the diffusion of useful knowledge, the discussion of subjects possessing literary and scientific interest, and for the free expression of native opinion on questions of social and political reform. The association flourished and spread through the province. It opened a "Free Public Library," and free "Reading Room," and popular lectures and recitations of native poets were ere long added to its other attractions. It has taken a leading part in the discussion of matters of social, provincial, and imperial importance, as is shewn by the documents connected therewith exhibited at Vienna.

Two movements inaugurated by the society, call however for more especial notice. One of its native members, an eminent Sanscrit scholar, Pandit Radha Kishn, the President of the Sanscrit Section of the Society in its literary depart-

ment, addressed a letter to government, suggesting that steps should be taken for the preservation and cataloguing of Sanscrit MSS., a movement which is now being warmly carried out all over India. He received a letter of acknowledgment from H.R.H. the Prince of Wales, then President of the London Sanscrit Text Society and Patron of the "Anjuman," a gracious act, which not only stimulated the labours of the society, but gave a considerable impetus to the second movement referred to, viz., the "Oriental movement" whose importance, in affecting the whole course of the Indian system of education, must necessarily be great. Its distinguishing features are described as follows:—

1. *The foundation of a national University in the Punjab,* —implying the development of self-government among the natives in all matters connected with their own education. The first step towards this end was to associate with the officers of government in the control of popular education the donors by whose contributions the proposed university was to be founded, together with the learned men among the natives of the province.

2. *The revival of the study of the Classical Languages of India,* viz., Arabic for the Muhammadans, and Sanscrit for the Hindoos; thus showing the respect felt by enlightened Europeans for what natives of India consider their highest and most sacred literature; without a knowledge of which it was felt that no real hold upon their mind can ever be obtained by a reformer.

3. *The bringing European Science and Education generally within the reach of the masses.*—This was to be done by developing the vernaculars of India through their natural sources, the Arabic, Sanscrit, and Persian, and by translating works of interest or scientific value into those vernaculars.

4. *The elevation of the standard of English Education to the level of the Reforms which are ever being carried out in Europe, and by studying Languages, History, Philosophy, and Law on the "comparative method," as adapted to the mental disposition of Muhammadans and Hindus respectively.*— The university was to be not only an examining body, but also a teaching body, differing in this respect from the other three Indian universities, those of Calcutta, Bombay, and Madras, which merely examine. It was also to be a centre of discussion on all subjects affecting education, and, finally, a matter of peculiar interest to us in Europe, it was to be an Academy for the cultivation of archæological and philological investigations, and for giving a helping hand to European Orientalists, whose inquiries it would advance by

researches on the spot, whilst it would itself benefit by popularising European Oriental learning, and bringing its critical method to bear on the literary labours of native savans. (*Vide* "P. U. C. Papers and Statutes.")

The scheme thus conceived, enlisted warm native support, and most liberal contributions poured in. Sir Donald Macleod, the governor of the province, gave his approval to the movement, and under his auspices a committee of European supporters issued in its favour a manifesto, which was among the documents exhibited by Dr. Leitner at Vienna. It was opposed, however, by the Educational Department and by the Calcutta university, although one of its vice-chancellors, Mr. Seton Karr, generously declared that, in his opinion, the time for the formation of a fourth university for Upper India had arrived. A long controversy ensued. Its progress may be traced in the files of the Indian newspapers exhibited at Vienna, and a reference to them will show the active part which Dr. Leitner took therein. A portion of the general Punjab scheme, viz., the movement in support of vernacular literature, was at length adopted in the north-west provinces, and eventually the Calcutta university was induced to make substantial concessions to the popular requirements, and in favour of Oriental learning.

Early in 1870 a "University College" was established at Lahore, and the Government colleges of Lahore and Delhi, the medical schools (English and vernacular), an Oriental college, law classes, and apparently a school in arts and industry, were affiliated to it. (*Vide* Prospectus.)

"On the recommendation of the Punjab Government" (I quote from the printed statement exhibited at Vienna), the Government of India in its order No. 9, dated 10th June 1869, sanctioned the foundation of the University College, it being stated at the time that the name of "College" had been added to that of "University," in order to mark that this arrangement was temporary, and that as soon as the University College created a larger number of students and candidates for examinations than had existed before, the full rights of an university would be conceded to it.

Meanwhile it is interesting to observe that the Lahore Government College, which began in 1864 with four students, counted in 1872 over 60 undergraduates in attendance, a proof that the impetus given to Oriental education has not diminished the demand for English. The men who have left the Lahore College are said to be among the most successful of native officials, employés, or private practitioners, and seem, as Lord Northbrook is reported to have said when on a

visit to that institution, fully to realise their duties to their fellow-countrymen.

Two universities, as may have been gathered from what has been already said, influence education in the Punjab.

Under these universities are, first, District, *i.e.* "Zillah "Schools," which prepare for the entrance examination of the Calcutta University in English, and in English and the vernacular for the Punjab University College. There are also mission schools, normal schools, adult schools, and private students preparing for the "entrance examination." Below the "Zillah" schools, which are subdivided into higher, middle, and lower, and are chiefly Anglo-vernacular, are a number of town and village schools, where Persian, geography, the vernaculars, and the 3 R's. are taught. There are also special schools, such as the Medical College of Lahore, the normal schools for teachers, &c. at Rawulpindi, Lahore, and Umritsur, and finally there is a vast number of indigenous religious schools for Muhammadans and Hindus. These indigenous schools are almost entirely conducted by priests, some of whom are believed to be profound Oriental scholars; but the studies in these schools are chiefly confined to the grammar and religious literature of the two classical languages of India, viz., Arabic and Sanscrit. In some of them also Persian, caligraphy, and a peculiar commercial cyphering are taught. The arrangements for discipline, regular attendance, &c. are very defective, but these schools being numerous and popular cannot be ignored in any popular system of public instruction. (*Vide* Dr. Leitner's Report as Inspector of the Rawalpindi Circle, and the amusing photograph of the rod in vogue in such schools, exhibited by the Indian Government.) According to the grant-in-aid rules of the Indian Government, they appear to be entitled to a grant from government, not exceeding half their annual expenditure, so long as they teach secular subjects in a satisfactory manner. Practically, the Christian missionary schools have hitherto been the only *semi*-religious schools, that have received grants in aid from government, and there seems to be no doubt that India is indebted to the missionaries for much of her education, and for the formation of a higher standard of practical morality.

In order to familiarise the native priests who, to a great extent, constitute the learned classes, with the results of European criticism, Dr. Leitner assisted in founding a critical Arabic journal for the Maulvis, and a Sanscrit journal (both weekly) for the Pandits. He also wrote the "Sinin-ul-Islam"

a book of which Part I. has appeared, containing "the history "of Muhammadanism, and its Literature, and their place "in Universal History." It was written for the use of the Maulvis, and its object is to familiarise them with the idea that their learning did not, as they have fondly supposed, stand alone in the world, but that it borrowed from western sources, just as on the other hand the European schools of the middle ages availed themselves of the labours of the Arabs. The civilising effect of such a work written in a spirit of candour and sympathy can scarcely be overrated, whilst it is alleged that its Indian style renders it all the more interesting to the learned men whom it is intended to attract to studies beyond their present scope.

In all the schools, whether indigenous or "aided," the teachers naturally vary in status and attainments. Generally it may be said that in the private "aided," as well as in the government schools of the middle and higher classes where English is taught, the teachers are well or fairly qualified; a few graduates of European universities being found among them. Above the head-masters of the upper district schools are the four inspectors of the Ambala, Lahore, Rawulpindi, and Multan Circles and the professors and principals of the government colleges of Lahore and Delhi. These officers are "graded," *i.e.* they have a vested interest in promotion to higher pay and position according to seniority and services; they are all graduates of European universities. The director of public instruction under whom they are placed has hitherto been a military man or a member of the Indian Civil Service (*vide* Punjab Educational Reports).

We now arrive at a new stage of Dr. Leitner's work. In 1870 he determined to devote his brief vacation of only two months to archæological investigations. His success is attested by the remarkable collection of sculptures brought to Vienna.* These sculptures (taken in connexion with the coins which also were excavated or collected by Dr. Leitner) illustrate, he believes, an obscure period of more than 1,000 years, say from 250 B.C. to 800 A.D. He regards them as having been executed by Indian disciples of Greek sculptors, introduced by Alexander the Great. Buddhism, which was then flourishing in Kábul, Balkh, &c., was encouraged by

* Most of these were exhibited there by Dr. Leitner. The remainder (some excellent specimens, presented by him to the Emperor's Cabinet of Antiquities at the "Belvidere,") were represented in the Exhibition by their photographs.

the Bactrian Satraps. Hence (he tells us) we find the kings wearing a Greek head-dress, easily distinguished from the simple top-knot of the ancient Buddhist. Greek games are being played by Indians, and the life and teaching of Buddha are illustrated by figures of men with European features, whose "protecting attitudes must not be confounded with "worship" of that religious founder.

Upon these sculptures Dr. Leitner bases new and interesting speculations regarding historical events, the history of art and the history of religion. The Greeks and the Buddhists influenced each other. Kandahar is clearly the Oriental Iskandahar, from Alexandahar, the town of Alexander. Buddha's miraculous conception by a ray of the sun, and his entry into a town seated on an ass, and preceded and followed by men wearing branches of the palm tree (in Tibet, a country where that tree does not exist) would indicate, not that Buddhism affected Christianity, but that the Jesuit missionaries left some traces of their labours, these latter scenes being apparently of later date and being found in connexion with the corrupt Lamaic Buddhism of Tibet.

In his holiday rambles Dr. Leitner also came across curious inscriptions and still more curious remnants of trade-dialects, and argots. He found spoken under the very ear of the magistrates of the frontier a "Thieves' Latin," in which criminals and subordinate native officials were wont to exchange thoughts. Among the goldsmiths and the Kashmîri shawl weavers he discovered a special alphabet and peculiar dialect totally distinct from the Kashmîri language. He reported on the peculiarly savage dialect of the Magadhs, a wandering tribe of Khorassanees, who gave our authorities some trouble a few years ago. He came across ancient sun temples with unknown characters inscribed on them. Still more interesting is his "discovery of the races and "languages of Dardistan," a term which in its widest sense includes the country between Kashmir, Kabul, and Badakshan, between the limits of 32 to 35 lat. and 70 to 74 long. Sir George Campbell in 1866 had moved the Bengal Asiatic Society to move the Punjab Government to depute Dr. Leitner to Kashmir, in order to inquire into the Chilasî dialect and the alleged identification of Chilás (a quasí independent territory lying to the north of British Hazara) with Kailás, or the Olympus of Hindu mythology. Although this view was erroneous, the true Kailás being in quite a different direction and overlooking the Manoserawera Lake, Dr. Leitner set out in search of Chilás and its dialect. He arrived at Srinaggar, the capital of Kashmír, in 1866, having

been there before during his long vacation in 1865, when he made an interesting collection of Kashmîri songs, fables, stories, poems, &c., &c., of which he was the first to present a specimen to the British public in his exhibited translation of the Dastán Shibli, also called the "Patience of the Saints." Here he underwent vexatious delays and hindrances, which he attributes to political motives on the part of the Maharajah of Kashmír, and of which, since his return to London, he has given interesting accounts in addresses delivered before various learned societies. He persevered, however, and after escaping two attempts upon his life (*vide* "Dardistan" Part III.) reached Ghilghit Fort, in which the Maharajah's troops bravely held their own against the independent tribes which had all combined in 1866 to expel his invasion from their country by an united effort. Dr. Leitner there met members of various races, some of whom he brought back with him to the Punjab, and from them he acquired a knowledge of several languages, "hitherto (with the excep-" tion of a few words, a list of which may be seen at the " end of General Cunningham's Ladak) entirely unknown." Hungry, thirsty, and surrounded by enemies, with one hand on the revolver, and the pencil in the other, he wrote down, occasionally by the dim light of a camp fire, the words and phrases which day by day were used in his hearing. The Dardus having no written character his progress was necessarily slow. It was only gradually, by having the natives in his house, by frequently repeating his questions, first to individuals, then to twos and threes together, and then by making one of these put these same questions to his companions, that it was possible to arrive at such approximate certainty as is attainable in so complicated a subject.

Once in tolerable possession of the language it was possible to proceed to songs, legends, &c., and whenever he found a man who knew a language with which he was already acquainted, Dr. Leitner was able to acquire new and to check old information. He came to the conclusion that Chilási, with Ghilghiti, Astori, and Guraizi were only dialects of the great Shiná language—a sister, not a derivative of the Sanscrit—and in 1872 he made the further discovery that in Kandiá, a district which lies between the Indus and Swat, another Shiná dialect, the Kiliá, was spoken. He also discovered the Arnyiá, or language of Chitrál, another sister of Sanscrit, and had the good fortune to obtain from two Bashgali Kafirs an account of the grammar and vocabulary of that almost mythological race, whose European appearance and manners have so long puzzled our ethnologists. Still more remarkable was his

discovery of the dialect of Hunza and Nagyr, "apparently "one of the remnants of a human tongue spoken before any "of the Indo-European and Shemitic forms were in ex- "istence." The Rev. Dr. Trumpp, in his review of Dr. Leitner's "Dardistan," Part I., says, [page 28] "The "public is indebted to Dr. Leitner for the discovery of "these most interesting idioms which . . . . will shed "many a ray of light on the development of the cognate "idioms in the plains of India. . . . . The Dardu "races like their brethren the Kafirs in the Hindukush, "are at present, from all we know, sunk in the deepest "ignorance, but the day is perhaps not far distant when "these members of the great Arian family will be re- "claimed, *which can only be done in the first instance by "an acquaintance with their language. He who opens the "language of a barbarous race, lays thereby the foundation- "stone of its future civilisation.*"

I have italicised these lines, as a justification for having said so much on a subject which might at first sight appear to be more philological than educational, and I will only add that not only has the whole country of Dardistan, with its many remnants of our great Arian race, been thus brought nearer to our educational operations, but a large amount of educational material has been contributed in Dr. Leitner's last publication, Dardistan, Part III., in the legends, songs, history, and accounts of the manners and customs, the roads, rivers, mountains, &c., of the whole range between Kabul, Badakshan, and Kashmîr.

In 1872, in consequence of ill-health resulting from sedentary overwork, Dr. Leitner exchanged appointments with the inspector of the frontier circle, and he was then enabled to verify many of his previous conclusions and to increase his linguistic collections by vocabularies of various Kafir dialects.

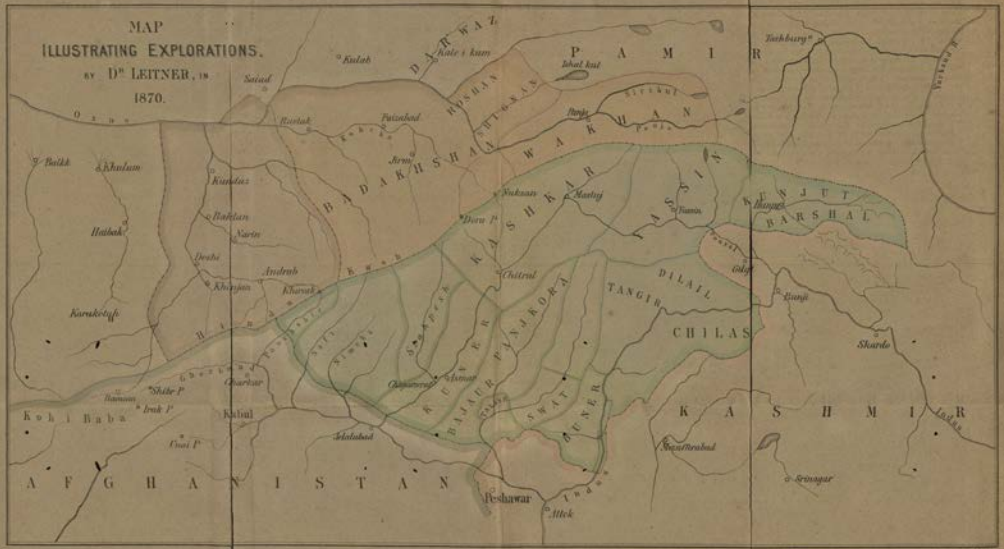
A Siah Posh Kafir, a member of that mysterious race which has been supposed to be descended from a colony planted in the Hindukush by Alexander the Great, and to which reference is made in the affixed descriptive Catalogue, having escaped slavery in Kabul, came to him for protection.

From the lips of this visitor Dr. Leitner committed to writing "The wanderings of a Siah Posh with Amir Shere "Ali, the present ruler of Kabul, in Turkestan, Herat, &c." This was exhibited at Vienna in the form of a pamphlet, and gives original information regarding events and places in Central Asia and the recent History of Kábul.

In addition to Dr. Leitner's other claims to the considera-

tion of the jury, their attention was directed to the liberality and public spirit which he had shown in bringing to Europe at his own expense, and with a view of furthering the elucidation of ethnological problems, members of races hitherto almost or entirely unknown. Thus, in 1869, Dr. Leitner brought over with him Niaz Muhammad Akhun, the first Yarkandi who ever visited Europe. He was at Vienna on that occasion, and he contributed to the exhibition of 1873 through his former master some of the first specimens of Central Asian industry that have ever been seen in Europe. On the present occasion Dr. Leitner has brought with him Jamshêd, the Siah Posh already referred to, as a living illustration of a race, whose arms and dresses formed part of his exhibition at Vienna. To the value of these services to science, distinguished testimony has already been borne. Sir Roderick Murchison in his address of 1869 referred to Dr. Leitner and to the Yarkandi as follows:—
"I cannot but advert to the praiseworthy conduct of
"Dr. Leitner, the learned philologist, who having been em-
"ployed by the government in the countries bordering upon
"the British territory, has recently while on leave brought
"to England a native of Yarkand and the first of his
"nation who has ever been in Europe, and who is present
"on this occasion. As this intelligent young man speaks
"several languages, including Chinese, and understands
"Hindustani, we may, judging from him, form a fair idea of
"how intelligent a people there exists beyond the north-
"west frontier of British India, and that as this country
"affords various products of fine wool, silks, and fruits of
"many sorts, besides numerous minerals of value, we may
"in the end largely benefit by sending in exchange for
"them our teas from Hindustan and manufactured goods
"from Britain."

To the Siah Posh Kafir more recently brought over by Dr. Leitner, and to the collections now under consideration, Sir H. Rawlinson in his address to the Royal Geographical Society in May last, refers as follows (*vide* page 62):—
"*Dardistan.* Dr. Leitner, the able and energetic *savant*
"who has contributed so much to our knowledge of the coun-
"tries lying between Badakhshan and Kashmir, has recently
"arrived again in England from Lahore, bringing with him
"a Siah Posh Kafir, as a living illustration of the ethnology
"of the region. He has brought also large collections of an-
"tiquities, statues, arms, and coins, the fruits of his own
"indefatigable researches; and also numerous manuscripts
"of such of the races as possess any written character. These
"latter, together with the Græco-Buddhistic sculptures


MAP
ILLUSTRATING EXPLORATIONS.
BY Dr. LEITNER, IN
1870.
PAMIR
DARWAZ
Kale i kum
Kulab
Salad
Ishal kut
ROSHAN
SHIGNAN
Sirikul
Panja
WAKHAN
Tashburg
Rustak
Faizabad
Jirm
BADAKHSHAN
Balkh
Khulum
Kunduz
Baktan
Narin
Haibak
Deshi
Andrab
Khanjan
Khavak
Karakotah
Nuksan
Mastuj
Dora P.
KASHKAR
Chitral
JASSIN
Yasin
KUNJUT
BARSHAL
Hunza
Gilgit
DILAIL
TANGIR
CHILAS
Punji
Skardo
Kabul
Jalalabad
Peshawar
Attok
Srinagar
Mansfarabad
KASHMIR
AFGHANISTAN
Kuh i Baba
Shibr P.
Irak P.
Cuni P.
Charkar
Ghorband
Hindu Kush
Sinkpeh
Sinaka
Sufi
KUNER
BAJAUR
PANJKORA
SWAT
BUNER
Indus

" brought over by Dr. Leitner, cannot fail to excite the " interest of all students of Asiatic history and ethnology. " The collections, I understand, are for the present deposited " in the International Exhibition at Vienna."

Much as our Indian system of education has, in spite of its imperfections, undoubtedly done, it cannot be said to have given culture, one of the highest marks of "Educa- " tion."

Native elegance and refinement wherever they still linger are evidently of Persian origin; thorough mental discipline and scholarly habits exist with Pandits and Maulvis, whilst a smattering of various branches of " instruction," to be more or less offensively paraded, is what we have given to the natives with our so-called English education. That this is not an overcharged statement will appear upon reference to the official "Remarks" published by order of the Lieutenant-Governor of the Punjab:—(Proceedings, No. 606, dated 18th Feb. 1873.)

" Neither the English language nor literature is taught " upon any scientific or intelligent system, and the success " of English education, as a consequence, has not hitherto " been marked in the Punjab. Nor has the system which " produces few scholars been more successful in producing " gentlemen. The Lieutenant-Governor desires that the " department take especial care that the good manners natural " to Oriental youth are not lost at school. This matter has " hitherto been neglected. If the result of sending boys of " good family to school is, as is now often the case, that they " return pert, conceited, and studiously rude and familiar, it " is no wonder that parents desire to educate their children " at home. English education is not a desirable thing if it " only signifies sufficient acquaintance with the English " language to write and speak ungrammatically, sufficient " acquaintance with English literature to be shallow, and " with English history to be insolent. English education " is to be penetrated with the spirit of the great English " authors; to imbibe some portion of their strength and " beauty, and nobility and gentleness, and wisdom, to mould " the life and character upon the models they have furnished. " This is the standard of education to which the department " must endeavour to rise."

True learning and taste among the natives of India are still Oriental, not English. The elaborate MSS., whether written in tracing, on paper, on leather, bark of the birch tree, canvas, or wood, by the hand or the toe, show an attention to detail and finish which cannot be too highly rated. The illuminated pages of MSS., written 1,000 years

ago, are fresher than any combination of colours in English show books; the pictures, in spite of a want of knowledge of perspective, very often seize the salient characteristics of a person, action, or scene, more vividly and minutely than the dark reflection of the photograph or the conventional drawing room painting. The colours on the Kashmir shawls or on other tissues, whether subdued or bold, are intensely real; the freshness of those seen upon the specimens exhibited by Dr. Leitner in Group IX., and for which a medal of merit was awarded him, seems almost to outlive the encaustic tile or marble on which they are painted. It is true that the grouping and the arrangement of colours are often grotesque, and that exaggeration, overlaying, and bizarrerie, may be charged against native artists, but, as a rule, the minuteness and elaborateness in every kind of carving show conceptions of beauty which form a basis of true education. A happy combination of Western with Eastern ideas, as shown in the Punjab movement, and for which Dr. Leitner has so earnestly contended, may be accepted as a wholesome reaction against an unreasoning condemnation of everything Oriental. Each, surely, may learn from the other. The subtle Eastern wit may quicken, while in turn it is steadied by, the matter-of-fact touch of the European; and something of its minute thoroughness be turned to profitable account as a corrective of superficiality and of hurried generalisation. The one will no longer consider that he has everything to teach and nothing to learn, nor will the other hold aloof, in sullen and apprehensive silence, as he sees one landmark after another of his ancient civilisation inconsiderately swept away. Each will take an enlarged view of things. The character of each will be raised and strengthened.

The care which natives take of their MSS., the ceremonious way with which they treat their sacred writings, and the costly layers of wrappers in which they are embosomed, are remnants of a reverence with which the spread of printing is everywhere calculated to interfere. Yet in the exhibited 2,000 or 3,000 pages of Tibetan printing from wood blocks, probably far more ancient than the era of its appearance in Europe, the leaves are preserved with a religious care which might well be commended to the attention of European students. And whatever the value of the exhibited central Asian geographies in the Turki language, or of the Tibetan astronomical tables, or of other exhibited historical, ethical, and poetical works may be, as educational models, they can scarcely fail to arrest the attention and enlist the sympathy of every intelligent and unprejudiced educator.

Since this Report was in the press, an interesting announcement has appeared in the columns of a recent number of the "Indian Public Opinion" newspaper, from which the following extract is taken:—

"The scheme of examinations of the Punjab University College has been at last sanctioned by Government.

"The examinations will commence on the last Monday but one in November, and the following certificates in arts will be awarded to successful candidates:—

"Certificate of entrance.

"Certificate of proficiency in arts; and,

"Certificate of high proficiency in arts.

"Prizes and scholarships will be given to the most distinguished students.

"On the 3rd December the Oriental examinations will commence. These are intended for Moulvis and Pandits who attain high proficiency in Oriental classes. Certificates of Pandit, Moulvi, and Munshi will be awarded to those who distinguish themselves in Sanskrit, Arabic, and Persian, and at the same time shew a competent acquaintance with subjects of general information, not inferior to that required in the entrance examination in arts.

"We believe that by the careful selection of examiners, not connected with any of the Provincial Colleges, and by the valuable check of *vivâ voce* examinations in all subjects, the reputation of these certificates may be made to stand very high.

"We understand the principles of the Punjab University College to be these: that no teacher should be allowed to examine his own pupils; that a thorough knowledge of few subjects should be insisted on in preference to a superficial knowledge of a larger number; and that, further, this knowledge should be tested by *vivâ voce* as well as written examination. These principles are excellent, and we hope they will be rigidly adhered to."

It will be seen from the above that the Government of India has finally resolved to comply with the wishes and representations of the friends and authorities of the Punjab University College; and that an important advance has thus been made towards the full attainment of the second great movement of the Anjuman-i-Punjab. [*Vide* pp. 278 and 279 of this Report.

APPENDIX.

INSTITUTIONS with which DR. LEITNER has been connected as shown by his LISTS and by OBJECTS and DOCUMENTS exhibited by him at Vienna.

(*a.*) The Oriental section of King's College, London, 1861.

(*b.*) The London Society of German Savans, 1864.

(*c.*) A debating society in London. (He also helped to found the Anthropological Society in Vienna in 1869.)

(*d.*) Raised the Lahore College from four to 60 undergraduates preparing for the English examinations for Arts and B.A. between 1864 and 1872.

(*e.*) The Anjuman-i-Punjab, with free public library and reading room, a number of departments in languages and social reform, affiliated societies, a journal, &c., &c. (between 1864 and 1872).

(*f.*) The Punjab University College having four faculties (in arts, Oriental languages, medicine, and law), besides its functions as a literary body, for which he collected over 32,000*l.* (between 1865 and 1871), besides annual subscriptions amounting to over 10,000 rupees.

(*g.*) The Oriental College, originally an Oriental School, which, with other schools, was supported by the Anjuman before the Punjab University College was founded.

(*h.*) Organised and opened to regular official inspection for the first time in the Punjab, 50 female schools in the Rawulpindi Circle in 1872. Was the first European President of a native committee on female education in 1864.

(*i.*) Started 22 Muhammadan and Hindu denominational schools by subscription, and a number of secular government schools, when in charge of the Rawulpindi Circle in 1872, opened a higher English school, preparing for the University matriculation examination by subscription at Gujrat, and helped to found schools at Lahore, &c., &c.

LIST OF DR. LEITNER'S PUBLICATIONS.

1. Introduction to a philosophical grammar of Arabic (being an attempt to discover a few simple principles in Arabic grammar, in English).

II. Dr. Leitner's Arabic grammar (in Urdu).

III. The same in Arabic (in course of publication).

IV. The theory and practice of education, with special reference to education in India.

V. The races of Turkey (a treatise in connexion with Muhammadan education).

VI. Sinin-ul-Islam, being a sketch of the history and literature of Muhammadanism and their place in universal history, for the use of Maulvis and European students of Urdu. Part I. (136 pages), contains the early history of Arabia to the year 1259 A.D. (Part II. will be published in the course of 1874).

VII. Dardistan. Part I. A comparative vocabulary and grammar of the Dardu languages (Arnyiá, Khajuná, Kalâsha, and two dialects of Shiná).

VIII. Dardistan. Part II. A vocabulary (linguistic, geographical, and ethnographical) and dialogues in the Shiná dialects (Gilgiti, Astori, and Chilâi), with copious notes.

IX. Dardistan. Part III. The Shiná race (their legends, riddles, proverbs, fables, customs, songs, religion, government, and sub-divisions). The encroachments of Kashmir on Chilás, Gilgit, Hunza, Nagyr, Dareyl, Yasin, and Chitrál. The massacre of women and children by Kashmir troops at Yassin. Chronological history of Dardistan from 1800 to 1872, including references to Mr. Hayward, &c., &c. The book contains 109 closely printed royal quarto

pages, exclusive of title page, preface, introduction, and table of contents. Each part of "Dardistan" is independent of the other, and is written for a different class of readers.

(Part I. for the philologist; Part II. for the future traveller in Guraiz, Astor, Chilâs, Gilgit, &c., &c.; Part III. for the general reader.) Messrs. Trübner, publishers, London.

X. Dr. Leitner's smaller pamphlets, such as his "Discovery of Græco-Budhhistic Sculptures at Takht-i-Bahai," the "Simla Dialect," "Adventures of a Siah-posh-Kafir, and his Wanderings with Amir Shere Ali," "Scheme for the Establishment of an University in the Punjab," &c. All the above books were printed at Lahore, at Dr. Leitner's press.

XI. The Spanish letters in Hingeston's "Royal and Historical Letters," &c., &c.

The following parts were in manuscript:—

1. A brief account of Dr. Leitner's adventures on a tour in 1866 through Zanskar, Ladâk, Little Tibet, Kashmir, Gilgit, &c.

2. A full account of Mr. Hayward's death (compiled from various non-official sources), and the precise extent and value of his explorations and statements in 1870.

3. The race and language of Kandiá or Kiliá (discovered by Dr. Leitner in 1872). The district lies between Swat and the Indus.

4. Further details regarding the legends, &c. of Chilás and other Shin countries.

5. The "Traveller's Vade Mecum," in the following Shin dialects:—Gilgiti, Guraizi, Chilasi, Kandiá, or Kiliá. Also in Kashmîri.

6. Various routes to Badakhshan, through the Hindukush, (from Srinagar, Leh, Peshawar, Kabul, and Abbottabad, through Kandiá, Chilás, Dareyl, Tangir, Hodur, Dir, Chitral, Kafiristan, Bajaur, Swat, Petsh, Daranur, and Lughman, &c., &c.) with the names of the chiefs and places of interest, references to local traditions, &c., &c.

7. A comparative vocabulary and grammar of the languages of the Hindukush, languages which have been either discovered or investigated for the first time by Dr. Leitner, including also the Kashmîri, elucidated by him.

8. An account of the countries and inhabitants of Lughman, Daranur, Petsh, Chitral, Bajaur, and the various parts of Kafiristan; with dialogues, songs, &c. in several of the languages.

9. A sketch of a secret trade dialect, and of the *Argots* on the Punjab Frontier.

10. The inscriptions, songs, and literature of Kashmir (text and translation).

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TECHNICAL PAPERS ON SPECIAL SECTIONS OF THE EXHIBITION.

(*Contributed by Mr. W. H. Maw and Mr. James Dredge.*)

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MR. H. W. SWENY.

THE BUILDINGS IN THE PARKS. EXHIBITS IN THE ROTUNDA.

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THE BUILDINGS IN THE PARK.

By Hugh Willoughby Sweny.

In an Exhibition which aimed at, and almost succeeded in being Universal as well as International, certain allowance should, and must be made for tentative efforts, and experimental trials, and it would be alike ungenerous and unjust to find faults in the execution of schemes undoubtedly noble in their conception. No excuse, however, is needed for the novelties, the buildings for new purposes, such as the Agricultural Halls, being so admirable that they might be accepted as exemplars for similar purposes for future displays. But when we come to the beaten track, in which the experiences of four *lustra*, and four International displays were available, we find much to blame and but little to praise, whether we regard the Industrial and Art Palaces from an æsthetic or practical point of view. For some of these shortcomings the architect was *not* responsible, as by his original plan not less than forty *vomitaria* were provided, a number increased by at least a half in practice, owing to the demand for space causing the majority of the open courts to be converted into "hofs," and thus sixty exits were provided for the rapid disgorging of the assembled crowds. But half an hour before the closing time police at the nave end of each transept blocked the way, and with the exception of some four or five points, known only to *habitués*, the only exit permissible was the South Portal, giving to the Kaiser Allée and the Haupt Allée of the Prater compelling anyone who wished to return by the north side to face a wilderness of shingle on his transit, only comparable to the "Spit" of Dungeness. Even the habitué who desired to reach a point either north or south, supposing him to have emerged at either the extreme south-west or north-west portal, was obliged to pace twice the exterior length of the Industrial Palace, or pay a second time, there being no connexion on the west side between the north and south portions of the park. As the police were the obstructive agents, and their employers were the Executive, on the principle of "qui facit per alium, "facit per se," the General Direction must be held responsible. This, though it may appear a trifle, was the subject of much complaint from the general public, and though frequently ventilated in the Viennese journals, this cause of complaint remained unremedied.

Thus much for the practical; now for the æsthetic. Firstly, as to the Rotunda, but from one point externally was it possible to gain a view of it in its entirety, and do justice to its colossal dimensions; of its interior aspect we shall have to speak anon. With this exception the general effect of the exterior must be considered as satisfactory, and in some matters of detail, excellent. These were the elaborate and spirited arms of each country, produced in stucco, placed over the entry of every "hof."

Internally, the Exhibition had nothing to commend, the depressed arch of the nave roof was most offensive to the eye, and *no* vista could be obtained from any point. Thus, in place of a large arch—as was suggested by some well experienced in Exhibitions—at the junctions of the naves and Rotunda the half gallery was supported by pillars that broke the line of sight, and gave a twoness, if we may use the word, to the entire structure. How fine a vista 3,413 feet in the clear from end to end, would have been, it is easy to imagine, and how such an opportunity should have been lost difficult to conceive. The descent into the Rotunda was another radical fault; and why the floor should not have had a raised platform with descent into the naves, a marvel to all who saw the good result of such an arrangement beneath the twin domes of 1862. Of the Fine Arts Palace it is but charity to say little; worse adapted for its purpose it could not

have been, and how it entered into the mind of any architect to so utterly waste space, to construct so many "wells"—for many of the courts were no more—cannot be divined, unless he wished to carry out to its fullest the theory of "windows that obstructed the light, and passages that led to nothing." Nor was the building less faulty in construction, the walls being in many cases so damp, that many valuable paintings were irreparably destroyed, and still more were seriously damaged. The materials of both the Industrial and Fine Art Palaces were rough brick walls, plastered or stuccoed over, and wooden roofs covered with zinc. The former were so hurriedly built as to be rotten before they were ripe, and to be tumbling to pieces before they were completed; and how the roofs were pervious to rain, the experience of many unhappy exhibitors can best tell. The Machinery Hall answered its purpose well, and if no attempt was made at ornament, there was at least no shortcoming in the matter of convenience. Of the Agricultural Halls, constructed solely of wood, mention has been already made, and congratulating their author on his success, pass away from the Industrial and Art Palaces, the Hall of Amateurs and of Museums, and the Machinery and Agricultural Halls, and turn to the main subject of the report, the buildings in the grounds.

Firstly, the entrances, and taking the principal entrance in the Prater Haupt Allée as an example, nothing can be found but praise, as nothing could be more charming than the semi-circular sweep of this South Portal, the grace and lightness of its woodwork *à jour*, the warmth of its colouring, and beauty of its decorations, and its towering twin Venetian masts, bright with their polychromatic Reiches Adler.

Nextly, the covered ways, which extended from each extremity of the South Portal to the Exhibition Palace, stretching first in a straight line along each side of the Kaiser Allée for a third of the distance, thence branching off at a right angle, then again in a straight line for a short space, passing in a quadrant at the back of the Jury and Kaiser Pavilions, turning off sharply again for a few yards, and then leading in a straight line to the Exhibition Palace, midway between the Rotunda and the two projecting wings that flanked either end of the Palace. The first portion of the covered way direct from the Haupt Allée contained on the left-hand the correspondence offices of the General Direction, each with its pretty little *patio*, its flower beds and trailing creepers winding round the wooden pillars, whilst on the right were placed the Post and Telegraph Offices and the Poste Restante Department of the Exhibition. At the north side of the Palace the covered ways passed in a straight line from each angle of the squares that enclosed the Rotunda to the Machinery Hall, to be continued at the opposite side to the Station of the Staatsbahn. Two similar "covered ways" connected the Japanese and Turkish sections with the Kunst Halle, enclosing the square containing the terraced, or rather sunken gardens, and the fountain of Achmet the Third. Thus it was possible to visit all the main features of the display on foot dry shod, to continue one's investigations in the same happy condition throughout the grounds was simply a question of bath-chairs and guldens, for those who like Dr. Johnson preferred the "vehicular to the "pedestrian mode of conveyance." In other respects the stained wood of which these covered ways were composed formed a charming contrast to the creeping greeneries with which the pillars were covered, and the asphalte footways made a royal road in comparison to the ubiquitous shingle that permeated every other pathway within the magic circle of the grounds. These entrances and covered ways were, whether regarded from a point of ornament or utility, simply perfect, and as a park will undoubtedly be an adjunct of all future International displays, Commissioners, whether Imperial, Royal, or Republican, will do well not to attempt improvements, but to rest contented with loyally and faithfully copying.

The covered ways, from another point of view were remarkable as containing the only gratuitous seats in the grounds of the Exhibition. Certainly the ubiquitous iron chairs with spring seats were as comfortable as the charge (five kreutzers) for using them was moderate, but this tariff only obtained in places where there was no attraction, as the seats placed around the orchestra were respectively 20 kreutzers for the inner ring and 10 kreutzers for the outer. This scale of prices was relished by no one with the solitary exception

of the proprietor of the Italian Caffé, who on fine days found his tables crowded with those who chose to enjoy their beer and Beethoven at a price infinitesimally more than the mere privilege of sitting in the ring. Six entrances gave admission to the Palace, of which only one was located in the Palace itself, namely, the West Portal. The other five entrances, composed of the woodwork *à jour* already spoken of, were that opposite the Machinery Hall, at the west side of the grounds, being the nearest to the halting place of the direct Vienna Tramway; the entrance giving to the Elisabeth Avenue, leading in almost a straight line to the entrance in the Haupt Allée, facing the station of the Tramway that passed over the Sophien Brücke; and the main entrance in the Haupt Allée giving to the Kaiser Allée, facing which, with direct passage through Industrial Palace and Machinery Hall, at the entrance north of the grounds were the entrance and station of the Staats Bahn. Even the palings merit more than a word, from their spear-headed ornamentation and the fact that they were undisfigured by pitch.

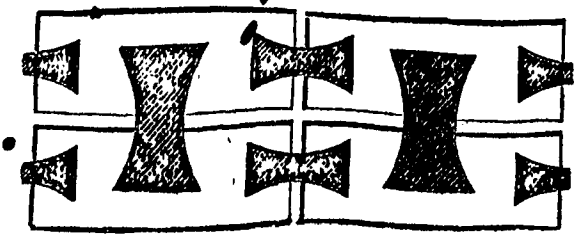
Within the ring fence, where lies the subject of this report, known as the Palace Park, the scene was always eminently attractive, whether before the opening, during the Exhibition, or in the latter days when all connected with the display from Chief Commissioners to proletarian workmen worked with an energy only equalled by that of dispair, to dismember what they had been so anxious to erect, and to return to their more or less distant homes. The phrase "before the opening" is rather a euphemism as long after the period alluded to, the grounds presented an appearance of chaos almost unproduceable on paper, the only idea that can be given is, an amalgam between a country intersected by rival lines of railway, each determined to anticipate its opponent in opening; those cheerful districts known as rising neighbourhoods handed over to the tender mercies of speculative builders; and some Nevada forest whose solitude is invaded by the sounds of the axe, and saw, and stalwart diggers, "fixing" their log huts.

To an artist's eye, the scene was eminently picturesque, here might be seen bearded moujiks with their flat caps, scarlet caftans, black velveteen knickerbockers and high leather boots, producing as if by magic charming carvings from rough planks with the aid of simple hatchets; near these were Slovaks, wild and unkempt, with their flapping canvas trousers, bare feet, and cacodorous sheepskin jackets; or Hungarians in "bèkes" and Hessian boots preparing some edifice for the resources of the Magyar kingdom. In another quarter might be seen the workmen of the Khédive ranging from white through every shade of "black and tan," the long eyed olive skinned Japanese reproducing distant Cathay in their bijou garden, or sharp featured, clean cut Persians reducing Lalla Rook to practice, and working with a will for the coming of their Schah-en-Schah. Fezed Osmanlis contributed their quota to the crowd, whilst beside them were white burnoused Moors, dignified as so many Abd-el-Kadirs, the name in fact of one of them. Add to this, Italians from every province of the now happily United Kingdom, Frenchmen in blouses, fair-haired Swedes, uniformed Prussians, English sailors, Styrians, Bohemians, Tirolers, and all the polyglot nationalities of Austria Felix, and it is not difficult to picture a series of *tableaux* as vivid in colours as they were quaint in costumes, whilst never, since the building of the famous Tower, if even then, did the faculty of speech assert itself in such a conflict of dialects and "confusion of tongues."

With the exceptions of the Kaiser and Jury Pavilions which occupied the sites originally intended for them, the buildings throughout the park were scattered with an irregularity which in itself added to the picturesqueness of the scene. The Rubicon of the Prater was the Heustadl Wasser, a cacodorous ditch with a high-sounding patronymic, and though many points of interest were to be found beyond it, the main features of attraction were fortunately nearer at hand. For general purposes of description, the buildings may be summed up under the heads of Brick and Terra-cotta; Wood, this being the most universally used material; Iron; Wood-framed houses with brick or plaster interstices; and Stucco. Some buildings contrived to combine all in their construction, whilst nomad populations might have fitted themselves with habitations from the "Kibitcha," of the Kirghiz to the marquée of the cricketer. The brick constructions were as buildings not worth noting, the bricks being simply used to line the pits containing the boilers, and form

the walls of the boiler houses. The boiler houses were the "Erste Brünner Maschinen Fabrik," in two stories, having two boilers of 100 horse-power, that of the celebrated G. Sigl of Vienna and Berlin, his works being at Wiener-Neustadt, with three boilers, each of 45 horse-power; the boiler house of Bœchle & Co., and of the Graz-Steinmark Waggon and Machine Factory, two boilers of 36 horse-power, and that of Tedesco & Co., of Prague, two boilers of 50 horse-power each; the four latter boilers being attached to the steam pumps connected with the waterworks and fountains. These four boiler houses belonging to the Austrian section. The American boiler house contained two boilers of 40 horse-power from the engineering works of Pitkin Brothers & Co., Hartford, Conn. The English boiler-house with its six boilers formed a very Mecca to engineering pilgrims, the exhibitors were W. & I. Galloway & Sons, Manchester, two boilers, 50 horse power; Daniel Adamson & Co., Manchester, two boilers, 40 horse-power each, one with steel plates, having double rivets; Henry Howard, Bedford, one boiler, 30 horse-power, and Cater & Walker, Grove Steam Boiler Works, Southwark, one boiler, multitubular, of 50 horse-power. The French boiler-houses were that of the Compagnie de Fives, Lille, containing two boilers each of 45 horse-power, and the boiler-houses of Weyher, Loreau et Cie., of Pantin, one boiler, 25 horse-power, and Chevalier & Grenier, of Lyons, one boiler, 40 horse-power. The Swiss boiler house contained a fine boiler of 50 horse-power, made by the Brothers Sulzer, Winterthur, Zurich.

Belgium had one boiler-house containing three boilers: two of 50 horse-power on a new system, the "Generateur Inexplosible" of Belleville, and one of 35 horse-power belonging to the Saint Denis Factory. That of the Deutsches Reich, like the English boiler-house, containing six boilers, two upright boilers, 40 horse-power each, from Carlshütte, Rendsburg, Sleswig-Holstein; 1 boiler, 60 horse-power, Jean Affolter, Chemnitz, Saxony; 2 boilers, 80 horse-power each, Paucksen and Freund, Landsberg, Prussia; and one boiler 30 horse-power, Dingler'sche Maschinenfabrik, Zweibrücken, Bavaria. In all 12 boiler houses, employed in connexion with the Machinery Hall and Waterworks Departments. Not to retrace steps, it may be as well to mention here the pumping stations, tanks, and other sources of water supply. A large tank of iron and cement attached to the boiler of Bœchle & Co., of Vienna, pump-house with low-pressure engine of Prunier, Lyons, requiring no well and sucking direct from ground, capacity 20,000 cubic feet an hour; the large water tower of the "Erste Brunner Maschinen Fabrik" for high-water service, which formed so conspicuous a landmark on the north side of the Industrial Palace and attached to the boiler house of Tedesco & Co., of Prague, two steam pumps of the Brothers Decker & Co., Caustall, Württemberg. These pumps drew their supply from a well, 12 feet in diameter, and 20 in depth, and supplied 10,000 cubic feet an hour. Messrs. Decker's pumps were more exclusively used with the fountains, but could also be put in connexion with the machines of the "Erste Brünner Compy." or that of Prunier of Lyons. Daniel Straub, of Geisslingen, near Ulm, Württemberg, exhibited two very fine turbine wheels, and Johann Fischer, of Korneuberg, a windmill for pumping. This machine was decidedly spasmodic and eccentric in its operations, and the disparity between the energy of the windmill and the scantiness of the water supply, rather a source of amusement than otherwise; and over the Heustadl Wasser was another machinery house for pump, exhausting this department of the display. Brick houses there were none, but a round tower and well in "clamped bricks," exhibited by E. Pavy, Mezières, Indre, were very noteworthy and doubtless durable, and a terra-cotta balustrade



fountain and wall with its medallions, statues, and pillars, the products of the Greppiner Werke, Greppin, near Bitterfeld, Saxony, seem admirably adapted for our climate in lieu of the stucco shams that with us replace honest brick and failing in the attempt to look stone are "spotty in sunshine and streaky in rain." The warm tone of this terra-cotta forms an admirable foil to garden greenery, and though when covered with trailing creepers, they charm the eye of the artist, these artistic specimens of terra-cotta will bear the severest criticism of the architect. The Wacht Hausen, constructed of wood and plaster, answered well their purposes, but merit no further notice; but where one has to speak of the wooden constructions, their variety of design, from the simple telegraph office to the ornate Russian farm house, call for the pencil and palette of the artist, not the faint pen picture that could be furnished by even the most graphic of "specials."

Entering from the gate facing the tramway that led over the Sophienbrücke you soon found yourself in a primitive woodland village, where, rudest of all constructions, was the Sennhütte and Walne from the Styrian Alps, bearing a close resemblance to its brethren in the Bernese Oberland. Formed of rough pine trunks with pent house roofs covered with shingles held down by heavy stones, they will be found throughout Styria perched high up the mountains on the debateable line where the mountain pasture ends and King Frost reigns supreme, and where an Alpine Horticultural Society would find it difficult to present a show of any plant but the Eidel Weiss. Under the eaves were bars to hold the dairy utensils, whilst against the Walne was the winter store of firewood, piled ready for use. Immediately at the side stood a pump of primitive construction, formed of the unbarked trunk of a tree. No line of windows disturbed the beautiful simplicity of this Sennhütte, the walls were no higher than the doorway, and the cooking apparatus was so modest as to dispense with the usual accompaniment of a chimney. The East Galician peasant house was a much more luxurious structure, boasting windows on each side of the door, and at the sides of the house, and the thatched roof and wooden chimney had a very picturesque effect when seen against a belt of forest scenery still spared by the axe. The Peasant House of Northern Hungary was much more ambitious, the walls were of planed planks, whilst a porch veiled the door, and a projecting balcony round the upper story furnished a pleasant shade, the roof of shingles being carried over the balcony and supported on wooden pillars, with rows of red and yellow maize hanging in festoons between them, and clustering hops and scarlet runners twining around, one might wish to see similar buildings imported into "Merrie England."

The Vorarlberg Peasant House was so elaborate that one would hesitate before setting it down as a precise type of a peasant house. Of three stories, counting one in the roof, built on a stone and rubble foundation, you entered the verandah on the first story by some three or four steps in front. On each story was a balcony, all supported by pillars carried up to the projecting roof, which, made as it was of fine shingles as the walls were formed of wooden scales, seemed only to need a monster shade to be placed on some Cyclopean mantlepiece. The furniture, however, was disappointing, suggesting too strongly its city origin, but the maidens, who all day long favoured visitors with performances on the zither and guitar, wore a startling variety of head-dresses, that no doubt will appear in myriad modified forms on the belles of London and Paris. Most picturesque of all was the Siebenburger Szekler House, with its all-o'ershading roof, its pilgrim porch giving a shelter to wayfarers, its gateway resembling much the "lych-gate" of many of our rural "fried-hofs," without, the quaint carvings of the gateway, with their patterns in red and blue, caught the eye by their semi-Oriental ornamentation, and within, the spectator found himself in Hungary. A long verandah ran round one side of the house, whilst from pillar to pillar festoons of maize made a decoration of their own, and two round steps, rough, or rather smooth, as when they were taken from the bed of their native rivulet, led into it. In a small garden, the peasant grew his maize and tobacco, whilst some rude farming utensils were placed at the further end of the courtyard. An open doorway of quaint pattern, with equally quaint door-posts, gave to a hall hung with pottery, and the principal room, with its beams, from which gar-

landed by wreaths of maize and groups of hats, its shelves and presses, its trophies of arms and masses of wooden pipes, its carved and painted chairs and tables, its inhabitants in their brightly-embroidered "bèkes," the uniqueness in form and pattern shown in the minutest object, made the Szekler-Haus the European feature in the dwellings in the park.

The rude nobility visible in all the surroundings of the Szekler-Haus may be partially set down to the proletariat aristocracy that exists in Hungary, even to a greater extent than among the Polish Slacheics, of whom it is said in a proverb, "If a dog is placed in the middle of a Slacheics estate his tail will hang over the boundary." In past centuries whole districts were ennobled; instance, the Ivzygiers, the Kumaniers, and the Croatian district of Turkopolje, and throughout Hungary these nobles were called indifferently "Seigniors of the Seven Plum-trees," or a less high-sounding title in a land where all wear high boots, "shoeless nobles." Indeed, all Szeklers without exception have been ennobled, so that however poor they may be they still retain the proud consciousness of their Magyar descent, tracing their pedigrees direct from the old Huns, and cherish traditions of the days when Attila swept over Europe, or when the Hungarians fought single-handed, now with the Moslem and now with the Austrian Archdukes, or perhaps of even later struggles that the world has not yet quite forgotten.

In immediate proximity was a white or rather yellow washed dwelling, of two stories (the upper contained in the red-tiled roof), with green jalousies and a basement story serving as a store-house; this known as the Siebenbürger Saxon House, afforded the strongest possible contrast to its Hungarian neighbour, as strong, indeed, as that of the Saxon colony, of whose architecture it is a specimen, who have retained their individuality totally apart for several centuries, preserved their language and national customs, and have refused to mingle with their Magyar neighbours, and no one who visited their house and compared it with its Szekler neighbour could fail to see the startling difference extending even to the minutest article of furniture. Still picturesque as it was, the principal room in the Saxon House was undoubtedly the kitchen, and the portentous display of cullenders, pans, jugs, and other utensils proved, however the Saxon colony have degenerated from the deeds of their ancestors, they still cherished their traditions of good cheer.

Beside this plaster dwelling, on the opposite side of the way was a plain two-story house forming almost a square, with planed planks, and no projections save on one side where the roof formed a small pent house, the Croatian house was certainly not remarkable for its picturesqueness. That of a Slovak peasant was as rude as its inhabitant, whilst a Roumanian log house with its quaint chimney, shingled roof and air of rough solidity, recalled the times of the "Pilgrim Fathers." "Miles Standish," "the Pequots ringing whoop, the soldiers wild halloo." The Pavilion of the Steirmark Proprietors of Forests, was naturally of wood, but that of the "Ungarischen Staats-" forstverwaltung," the Royal Hungarian Woods and Forests, resembled rather a cathedral in wood than a temple of forestry. Built in the form of a Greek cross, in its spire it reminded one of the Týnský Chràin, the Thein Kirche of Prague in its four miniature steeples at each corner, and its open porch and gallery, supported on pillars open to the air, gave it with its scale covered roof a unique charm even where every building possessed its charm of quaintness and idiosyncrasy. Within, the polished walls and wooden pillars, the open tower of the spire, the eagles soaring from the roof, the stuffed birds and beasts, the collection of flowers and trees made it a bourne as much in request by savants as it was by inquiring visitors. The entire wood industry of Hungary was illustrated by specimens of the various timbers both in a rough and polished state, and by models; there was to be seen the mountain raft, to be found sometimes 600 feet in length, with its fastenings of bark cables; the "lorry" with its timber burden drawn by four men; the wire cables stretched from tree to tree and rock to rock by which huge trunks are lowered down otherwise inaccessible precipices; the "Steinfang," or palisades set in dangerous places to catch the avalanche of stones rolling down the mountain sides; the "holzriese" or wood slide, a trough formed of roughly dressed tree trunks; and all the rude surroundings of the charcoal burner's hut.

We shall now speak of the wooden building *par excellence*, the Farm

House of the Chevalier de Mlodecky. No description in pen and ink can do it justice. There was the farmhouse with its projecting roof, rich with carvings its windows with their sills painted to resemble damask cloths, its exquisite porch, its gateway of elaborate construction, its offices running all round its open court, all rich in carvings, and when we say that the cost was no less 30,000 guldens, and the workmanship was entirely the work of the hatchets of *moujiks*, some idea may be formed of the elaborate character of its beauty. The purchaser of it, and sufficient wood to build a similar house, for 3,000 guldens in all, may be congratulated on an excellent bargain. The furniture was essentially Russian in design and execution, and was so sumptuous that the Sclavonian farmer must evidently be a man combining the tastes and fortune of a Beckford. Chairs, tables, and settees were of walnut, carved clock cases, quaint shelves covered with quainter earthenware or glass of Muscovite design, presses filled with linen, remarkable for its rich embroidery, were all so ornate that one almost doubted the reality of the scene till one saw the burnished *samovar* standing ready on the stove. The huts of a Ruthenian and Cracow peasant, and two Geydeler Houses from near Pressburg served admirably as foils, and a Swedish dairy, Austrian School-House and Gymnasium, a handsome two-storied building, with shingled roof, a large planked Pavilion for stained glass; the two storied wooden structure used as offices by the Vienna Photographic Association; the red and white striped tent-like Ambulance und Sanitäts Verein; an Iron Church; the Stable of Baron Pittel; the cow sheds, with marble troughs of the Vienna Agricultural Society; a Croatian beer house, shaded by pretty creepers; a Tiroler Bier Halle; two sheds containing monster oaken vats, exquisitely carved, that put the great tun of Heidelberg to shame, and military barracks made up the strange congeries of buildings over the Heustadl Wasser, still further added to during the Cattle and Horse Shows by long rows of sheds, and a Gulyà or corral where long horned Hungarian cattle were tended by long haired herdsmen and longer haired dogs, both having for a common home a tent-shaped straw covered hut.

The Swedish and Norwegian Fishery Pavilions, the former especially, with their scale covered walls, and the Swedish Restauration, kept by Theodor Blanche, with its open verandah running round three sides, and to the sloping pillars of its portico, possessed a quaint beauty of their own, concerning which visitors to the Alexandra Palace in the ensuing summer will be able to judge. Sweden indeed came to the front in her display of buildings, having in addition to these in wooden structures a School House, which was warmly praised for its arrangements by all interested in education, a handsome Hunting Pavilion of two stories, with an octagonal porch and a spire painted black with slate coloured ribs, this, unlike similar buildings, was painted of a buff colour, having incised patterns on the pillars, relieved with a darker shade; and two War Pavilions, the one, covered with canvas having longitudinal stripes of blue and white, containing a series of military models, uniforms, and arms of precision, guarded by a gunner in the full dress of the Swedish artillery; the other, its roof being of iron tiles, displaying ordnance from the brass field howitzer to the large breech-loading cannon destined for some fort, transport trains, and life-boat apparatus.

The Pavilion of the Tsar, with its coffer-shaped roof, with green and yellow lozenges, spire crowned with a three sided eagle, giving the double-headed bird of Russia from every point of view, its exterior gallery and staircase, formed, with its green setting of trees, a striking object in the grounds and its internal capabilities were a matter of wonder to the few who were allowed to enter. You passed from the outer porch into a long hall, hung round with the flags of all the Russias, and of the various nationalities presided over by the Tsar, including Circassia and Poland; from this you entered the dining room with its massive oaken furniture, and exquisite maiolica stove; beyond were the bedroom of the Emperor furnished *en suite* in sycamore varnished, the bed, never slept in, having at its head the arms of the Romanoffs surrounded by the collar of St. Andrew, and a coffer at foot also in varnished sycamore, was handsomely decorated with hinges and clasps in nickel. In a corner of the room, with a lamp burning constantly before it, was a picture of the patron Saint of Russia, being as with us St. George, and at the side of the bedroom,

were on the left a charmingly fitted up dressing room and a tiny chapel with a small white marble altar adorned with pictures of saints after the Byzantine school. Amongst the wooden erections were a portable house built on the patent of "Martin Kien;" and a very comfortable *cottage ornée* it made with its campanile giving a pleasant smoking room on the second story, and its open air terrace. Within were a drawing room, boudoir, ladies' room, bed-room and kitchen. Another Pavilion, that of the "Little Child," though not remarkable from an architectural point of view, was a constant source of attraction to an endless stream of cosmopolitan mothers and maidens. The Pavilion of the Austrian Lloyds with its full rigged mast attracted attention by its singularity, and that of Anton Dreher's Brewery with its copper dôme, its four porches, each shaped like a half barrel and supported by caryatides, displayed much architectural ingenuity.

The Pavilion of the Prince of Monaco was of more interest for its contents and garden than any external beauty, its interior being a perfect paradise of perfumes, choice maiolica, and artificial flowers, that in this scented atmosphere seemed to bloom, whilst the garden recalled in its semi-African vegetation, the sunny slopes of the Rivièra; whilst the Moorish Pavilion, if anything plainer, displayed for its size the largest amount possible of white wall with the smallest modicum of windows. Within, it was a little gem, containing the entrance "Midhal," with its tiled floor and walls, set apart for the master of the house to receive his guests, the patio "El louest de "dar," having on its right the dining room "noegh," at its end the salon "bith el kebir," and at its left the ladies' bedroom "bith el sghir;" the bath room, "hamam," the kitchen, "cotshira," and Numero 100, "ein thaher." The arabesquerie of the decorations, the alhambresque arches of the doors, the antique Moorish embroidery hung around the rooms, the rich cushions, arms, and dresses displayed made this, from its perfect truth and genuineness, the house having been constructed at Tangiers, one of the sights of 1873. The "Kouba" or cupola, in the "midhal" or entry was carved and painted in mathematical figures and took a master workman and four assistants forty days. At the entrance to the "patio" in Arabic characters was the inscription "In the name of God, God's blessing to the servant of God. To the Sultan "Franz Josef, whose life may God prolong." At the tiled seat in the entrance the host receives his guests, and from the cistern facing, poor travellers or neighbours can procure water; the outer doors are sometimes open, those giving to the "patio," never. These doors are not hung on hinges, but on bevils set in capsules let into the walls. A smaller door let into the larger, in every instance, admitting to the "patio" and to the saloon, the small door to the ladies' saloon being called "Bab il arja," or the lame door, as it has no support on one side when opened. This house had the "patio" roofed in as a climatic necessity, but in Morocco it is invariably open, the central space being occupied by a fountain or more frequently still by a fig tree, thus allowing the master of the house without metaphor to sit beneath the shadow of his own fig tree. The four capsules that project from the pillars supporting the gallery are termed shoes, and the grating surrounding the gallery itself was called by a very literal name "darbous ein aineemam," gallery to peep through. In fact the Moorish lady of the house can command a view of her husband from every point, that is when he is at home, for there are small windows screened by curtains in both the salon and ladies' room, and as in the dining room "noegh" only near male relatives of both families are admitted, cousins even being "tabued," madame at any moment can convince herself of the identity of the guests. This "noegh" was simply furnished with a divan running round three sides, some round seats "estormirs" and a small table some three inches above the floor. Such was the mere furniture, the hangings may, as with our pictures in similar rooms, represent any amount, and the arms, priceless as indispensable, hung here in a recess ready to hand. In this room, too, sometimes hangs the rusty old key, of which Longfellow sings so sweetly, the key of the old house in pleasant Grenada, a souvenir of the days when the Alhambra and Alcazar were in their prime, before Boabdil el Chico took his last look at his city from "Il ultimo sospiro del Moro," and as his mother said "wept as a woman for that which he had not courage to defend as a man."

The East was here around us on every side ; behind, the twin minarets and dome of the Khédive's Palace soared upwards ; beside, were the garden, temple, and houses of the "Land of the Rising Sun," and facing was the Pavilion of the Schah-en-Schah with the Lion and Sun emblazoned on its front and the green and white flag of Persia floating from its roof.

The Pavilion was two storied, the central portion projecting and forming a hall approached by a flight of steps on each side. The entire front of this projecting portion was a mass of mirror mosaic in tiny panels interspersed with garlands of fruits and flowers, and surmounted by a cornice also glittering in mosaics. The dazzling effect of this, glistening and glinting in the rays of the sun it is impossible to describe, recalling as it did Alladin's palace in its brilliancy. Passing up the steps into the entrance hall, you emerged from sunlight into a shade tempered by various coloured rays of light falling from two windows of Bagdad make set with piecework of glass in mathematical designs, a large hall the height of the two stories by a double staircase led to the Schah's chamber, a veritable Hall of Mirrors, mirrors covered the walls, the doors, whilst the ceiling and cornices were one mass of mirror mosaics. Round the centre of the platform was a circle of fishes that seemed to swim in the mirrors on which they were painted ; at each corner were baskets of flowers set in looking glass, and the alhambresque cornice of the roof was a mass of glistening stalactites. This style of decoration is known in Persian as Ainé Kary or Ainé Bendé, and both within and without was the work of two artists from Teheran, Usta-Hassan-Ali and Hassan Ali, all being carried out under the superintendence of Mirza Petros Khan, the Persian Commissioner. This chamber, save for the furniture, which was European, was an exact reproduction on a smaller scale of the "Schams-el-emaré" or Ambassador's Hall in the Schah's Palace at Teheran used for night receptions. Here the Schah remained some time when he paid his solitary visit to the Exhibition, and, if reports are to be credited, did not content himself with the visions of Fadladeen, who tells us that in Paradise "the righteous shall be "given to drink of choice wine, sealed, the seal whereof shall be of musk," but preferred the earthly brand of Rœderer, possibly for the reason that though "Mahomed verbot den Wein, doch vom Champagner sprach er nicht."

In the immediate neighbourhood was a group of Turkish buildings consisting of a dwelling-house, a Café, a Bazaar, and a large building of rather nondescript architecture called the Cercle Oriental. Without, the Turkish dwelling-house was simplicity itself, the frame being of woodwork, constructed, however, with great skill and nicety, the flat roofs being covered with the ordinary red gutter-tiles, the material used indiscriminately in the land of the Sultan, "pauperum tabernas, regumque turres." This weatherboard house, as it might be called, differed only from our own in having the inner and outer walls of split deal, both being covered with plaster, the hollow wall serving the double purpose of retaining warmth and excluding sound. Within were two staircases, the principal leading to the "Hareem;" the inferior, that set apart for the master of the house, passing by the kitchen and leading to the men's apartment, the "Selamleek" or "Peace be with you." Passing by the kitchen, one noticed a turnstile like a crèche at a Foundling Hospital, made so that food could be supplied to the dwellers in the "Hareem" without desecration from the eyes of strange men. In the "Selamleek" the East and the West were blended ; there was the "mangal" or brass stove occupying the centre of a Turkish carpet, in which the footsteps seemed to sink, "tandours" or tables, and a divan which filled up one side, all these were purely Oriental but the chairs and sofas, save for their costliness—tortoiseshell inlaid with mother-of-pearl—were Occidental, and might be transferred to any boudoir in Belgravia. The ceiling in this room was of Arabic design, and amidst a mass of arabesques bore, cunningly hidden under the guise of ornament, this inscription, "Ya o Mashallah," "Here is the King," whilst the curtains with their patterns of blue, red, green, and gold also bore the Sultan's "toughra" or sign-manual, and a piece of tapestry embroidered with burlesque figures of men, showed that the Koran is not now strictly observed, even in Istamboul. Crossing a lobby with lattice windows, the work of Bagdad artificers, you passed into the "Hareem" with its upper windows of stained glass, its doors of olive wood inlaid with exquisite mosaic

arabesques of mother-of-pearl, its chimney-piece with daintily sculptured arched recesses of that pure white which may be termed the father of all marbles, for it comes from the Marmora Islands. Around were gilt "knoduos" for vases, divans with cushions of gold embroidery on a ground of rainbow tints, curtains of maroon and gold shading the eight windows, and serving as doors to screen the entrance to the bath. Above was a ceiling surpassing in elaboration even that in the "Selamleek," and in this instance purely Turkish in decoration. Both these ceilings were marvels of skill and patience, and their artists, Megerdich Babalian and Thomas Tuck, both natives of Constantinople, were evidently proud of the effect they had produced. Hearing the latter name, the writer could not resist the remark that in our English calendar we numbered an eminent mullah known as Friar Tuck, when he was told Thomas Tuck was born of English parents, and being left an orphan in Constantinople was adopted by Herr Montani the architect. The Turkish House must, however, not be quitted without mentioning the bath, the ground floor containing the "hypocaust" or heating chamber, and the bath itself consisting of two rooms leading from the Hareem. Both had walls of and floors of marble, and though the writer's stay in the inner room or *sudatorium* was brief, it being heated at the time, and a Turkish bath in European costume not to be entertained for a moment, yet there was time enough to observe the marble bench, and the cupola roof with its bulls' eyes lights. This house though only one of a wealthy *bourgeois* was sumptuous in all internal fittings, and contained within much more space, eleven chambers in all, than would ever be imagined from its external appearance.

On the left of the house was the Bazaar, formed like the house of a wooden framework, and roofed with the usual gutter-tiles. Below, the bazaar portion was open, the upper story being supported on flat brickwork arches. Next door again was the Café Turc, a very pretty wooden building, having a verandah, accessible by some dozen steps. Here obsequious attendants brought you as you seated yourself tchibouques ready lighted, first placing on the floor a brass pan and provided you with genuine Turkish coffee in tiny "Zarfs." At the extreme corner of this range of buildings was the "Cercle Oriental," approached by a high staircase leading to a verandah on the second story. Its orientalism was rather bizarre, one of the side Pavilions being Turkish, the other Chinese in design, whilst in the rear was a tea house in what was supposed to be Siamese in character. All these were designed by Herr Montani, an architect of great repute in Turkey, who has the appointment of "Court decorator to the Sultan." His was also the design for the Sultan's Treasury, placed in the Turkish Court, in which the treasures of the Imperial Scimitar were for the first time displayed to dazzle the eyes of Western nations. The chamber was approached on two sides by flights of steps, the lower story serving as a store room for the least valuable portion of the display. Within was a handsome dome roof rich in arabesques and gold, but the true attraction was necessarily the contents, of which it is not my province to speak at length, but simply say it included the throne of Nader Schah, a loot taken by Sultan Achmed II., under the walls of Bagdad, and weighing no less than 150 ocks, or four hundredweight of solid gold, that, however, being its least value, as the gold was barely visible, each inch of space being covered with enamels in celadon, emerald green and ruby red, yet with a lavish profusion of pearls, rubies and emeralds. Of the other treasures in diamonds, rubies and emeralds, it may be sufficient to mention that they are estimated at a low figure when five millions and a half sterling is put down as their value, and that they and the armour in which they are set required five railway wagons for conveyance.

Standing in the terraced garden, between the east end of the Industrial Palace and the Kunst Halle was an exact reproduction of the famous fountain of Achmed III. with its gilded and painted arabesquerie, its marble basins and projecting eaves crowned with cupolas. Each corner was circular, having richly gilt trellis-work windows and the four fronts, all dissimilar in design, were covered with reliefs of flowers and fruits richly gilt and painted, while "round and about and in and out" ran inscriptions in golden characters on a blue ground, telling us "That all things live by water," or praising the uid to be quaffed within, saying that its "waves surpass the Sem Sem of

Mecca and the well of Paradise, Selsebil," which as the fluid on this occasion was Prater water said very little for the merit of these two historic springs. Within was a marble basin, from which a refreshing fountain sprang occasionally to greet the bystanders. There was a certain irony of events in the position of this model, as Prince Eugène of Savoy, "our good Prince Eugène," who now rests in St. Stephen's, so effectually beat the troops of this same Achmed III. at Belgrade and Peterwardein as to stem for ever the tide of Moslem invasion, it being the third and last occasion on which the Sultans tried conclusions with the Kaisers, the first being when on the 26th September 1529, the Sultan Soliman II., conqueror of Syria and Egypt set himself down before the walls of Vienna to be defeated by the bravery of Count Salm; and the second in 1683, when brave Starhemberg and John Sobeisky routed Kara Mustapha beneath the vineyards of the Kahlenberg, and saved the Kaiserstadt.

With its numerous courts, its twin minarets, with triple galleries, its lofty dome surmounted by the crescent, and its flat-roofed house with hive-shaped *columbarium*, the Palace of the Khédive was in itself at once palace, mosque, and mansion, a monument both of munificence and taste. The proportions of the building were palatial, but it was not till one stood under the interior of the dome, that it was possible to even faintly realise them. Although only built of brick and stucco the alternate bands of yellow and red with which it was painted gave it the appearance of a solid structure of sandstone of the two hues, with the exception of the Egyptian house at the rear, which in the sad monotone of its grey seemed to have been plastered with mud. Within the palace was a summer smoking room on the ground floor, having on one side a large projecting bow with handsome iron gilt gratings, round which ran a divan, where it was but necessary to sit for a moment to find at your elbow a courteous Nubian who tendered to you the hospitality of coffee and tchibouque. In a recess was an admirably painted panorama of Cairo, and beside, still on the ground floor, the winter reception room with its marble floor, its soft cushions and pleasant gurgling fountain. There were green courtyards, a reproduction of a Rock Temple with hieroglyphic covered walls and a range of stables where patient buffaloes, anything but patient camels, and Egyptian donkeys held daily levées, and in the yard attached was a specimen of the water wheel with its pendant jars and tank unchanged in form or fashion from the days of the Patriarchs. Above long open galleries gave to the inner courtyards and led to the Hareem, sumptuous in carpets, ceilings and embroidered cushions, a *réplica* on a larger scale of that in its Turkish neighbour. The inner dome of the mosque was brave with gold and colours, ostrich eggs and pendant lamps, and everywhere a soft subdued light fell from the many coloured Bagdad windows.

Nearly all the Westerns who did business in the Park catered for the creature comforts; the Orientals took a wider view, and trafficked in every imaginable production. In the Palace of the Khédive, a carpenter, with saw similar to those shown in Mr. Holman Hunts' "Shadow of Death," made neat boxes, his neighbour plaiting bright-hued silks and gold thread round cherry sticks, meet pipe tubes for an Emperor, only Emperors as a rule do not smoke pipes, the late French Cæsar consuming cigarettes; the Austrian Kaiser, the strongest "Italieners"; the German Kaiser and Russian Tzar, cigars of what nationality we know not; a man embroidered exquisite slippers in gold and silver thread, whilst a jeweller ensconsed in an angle of the building, sold sham sequins in the guise of earrings and brooches at prices it may be supposed were remunerative. Nacre merchants from Bethlehem sold olive wood carvings, mother-of-pearl crosses and Christian emblems, under the very shadow of the Turkish House, with such success that a perfect colony of their brethren assailed the terrace on each side, extended to that of the Khédive, and even set themselves down before St. Stephen's, and other churches in the Stadt. In the Turkish Bazaar you found genuine Latakia and Turkish tobacco, which though possibly genuine was not nice, and all around were booths for fezes, carpets, bracelets, slippers, pipes, arms, and all the conceivable articles which make up a Turkish store; sweet-scented bracelets "moved off briskly," and it was rumoured that these Eastern productions kept 40 women and children busily employed in Vienna

in their manufacture. Here were the Syrian with his long robes, the Turk of to-day differing from us only in the fez, the Armenian with his hanging sleeves lined with satin, the Arab in burnous, Greeks of the Isles, and Odalisques in the Café Turc, whose dress was so Oriental as to be utterly unlike anything to be seen in the East, a grave Persian merchant sometimes paced up and down, whilst the Japanese, some in native, though more in European costume, did a business requiring the efforts of two policemen to keep the line. This corner of the park was indeed a series of contrasts of the Old and New civilizations, of the East and of the West; Turkey, Morocco, Persia and Egypt, were set in rivalry; whilst the Land of the Rising Sun displayed its modest architecture; and modern luxury furnished the glass palm house of Waagner and the dainty orchestra where Johann Strauss and Langenbach delighted with their magic strains.

At the entrance to the Temple Garden of the Japanese were displayed two long oblong flags covered with legendary paintings of heroes and deities. On each side of the central walk were booths similar to those to be found everywhere in Japan near the temples of Shiuto. The entrance portal, formed of plain unpolished pine, is known as the "Tori-i," and the equally plain wooden railings that surrounded the garden as the "Seki-Hi," or Barrier of God. A strong contrast to Chinese dwellings was given in these buildings of their nearest neighbours, all being of deal, some doubtless exquisitely carved, but all unpainted, unvarnished, and unpolished, it being the Japanese custom for their houses whilst it symbolizes in their temples the purity of the Deity. The booths were provided with outer shutters of wood that slid on grooves, and inner screens that served as windows, paper being used in place of glass. A theatre or music-house, "Kagura-dò," an accompaniment to every Shiuto temple, was distinguished from the other buildings by the exquisite carvings of fruits, flowers, fowls, and fishes that supported the platform and roof, and the music of Japan was represented by three curious looking drums, known as "Taï-ko," "Simé-Taïko," and "Tudzûmi." A tiny bridge led over a miniature lake to the "Tenshiocodaidjingou," or "gou," temple, of the Goddess of that name, the common ancestress of the Japanese, from Ten-no, Ten-shi, or Mikaido, Master from Heaven, to the poorest proletarian. Mounting a small flight of wooden steps, you saw within the copies of the Imperial Regalia, "the mirror of truth," "the sword of justice," and the curved jewel that represents mercy, whilst beside hung waved strips of paper, known as "gohé," on which worshippers inscribe petitions to the gods their ancestors. Behind the temple stood a tall mast, "Sakaki," from which floated a curious flag, filled with air and shaped like a fish, called the "Koi-no-nobori," or Fish of the Mast, used to celebrate the Fête of the Boys, which occurs annually on the 15th May, and which floats as often before Japanese houses as the matron honours her lord with his miniature likeness. Quaint bronze and stone pillars, by name "Tolo," were scattered about the garden, and a trough or lavatory, "Tio-dzubati," for use before praying, stood immediately beside the bridge. On fête days other masts decorated with parti-coloured streamers and crowned with green branches gave variety to a scene which in all its quaint simplicity is transported bodily to Muswell Hill.

The Orchestra in the Mozart Platz, where Strauss and Langenbach held sway, was bright as colour could make it, and its site, backed as it was by a belt of trees, the most charming in the entire grounds, and one of the many examples of the good taste of the Empress Elisabeth. The Alsace-Lorraine farm house, one of the prettiest timber framed buildings even amongst many, with its dormer windows, pleasant court and interesting museum, was the solitary victim to fire of the year, and richly merited a better fate. The Pavilion of the Ackerbau Ministerium with its sexagonal dome; the Pavilions of the Staats-Bahn with cupola; the Ferdinand Bahn, with its four towers; of the Nordwest Bahn; of Archduke Albrecht; the Prince of Saxe-Coburg-Gotha, and of Prince Schwarzenberg were all striking examples of timber framed buildings with bricken interstices, and were all so remarkable for the wealth of their contents as to need each a description for themselves. Those who visited Vienna will not readily forget either the interior of the Schwarzenberg Pavilion, its pretty garden, its ponds of fishes, or those rare specimens the

European beavers from the Prince's estates in Upper Austria that drew such crowds by their natatory gambols. Krupp had a Pavilion to display his monster guns, the Pavilion of Germany its neighbour, was devoted to the arts of peace, the Pavilion of the German Empire in one of the quadrangles of the Rotunda, was Imperial in its richness as unique in its ornamentation, whilst that of the French Commission exhibited, especially in its internal fittings, the well-known taste of *La Grande Nation*. The Danube Steamship Company had its Mansard roofs, and Corinthian pilasters, and exhibited within three engines of full size complete, models of all the vessels in the service of the Company, together with their system of towage; the Spanish Pavilion was remarkable for its semi-Moresque architecture, the St. Marxer Pavilion for its caryatides, and Italy disdaining a pavilion gave a representation of the Italian side of the Mont Cenis Tunnel, the size of nature, train and all complete, the only drawback to the *vraisemblance* being, it required a vivid imagination to picture the mountain that towers for miles skywards over the original.

A solidly constructed edifice of two stories for the centre, and one for each of the wings, with handsome Ionic pilasters, testified to the enterprize of the "Neue Freie Presse," whilst a constant stream of visitors watched the perfection of printing displayed in one of Sigl's presses, whence a huge roll of paper hung above the machine was delivered into their hands a newspaper printed and folded, exclusively by machinery, in the space of a second. One exception must be made to the general poverty of display in brickwork in the Triumphal Arch of the Vienna Brick Factory; polychromatic and prismatic in its ornamentation, as it was noble in its design, it formed a fitting entrance to the Garden of the Kunst-Halle, and made one lament that brickwork elsewhere is not made similarly attractive. This square, with Kunst-Halle, Halls of Amateurs and Museums, and Triumphal Arch forming its sides, was marvellously effective, the exteriors belying their interior architecture. But though all these may be forgotten, no visitor will ever be oblivious of the Austrian Semaphore, Light-House and Fog-Signal, as the dismal humming of the latter, like that of a Brobdingnagian bee, effectually warned those within any building that time waits for no man, and that their internal ramblings for the day were ended, whilst music had no power to soothe its savage breast, and Strauss' stood with uplifted baton, as violins, bassoons, trumpets, and even the big drum surrendered to the power of this "Symphonie diabolique."

Possessing a likeness in unlikeness, the Kaiser and Jury Pavilions harmonised sufficiently in outline for the effect required, the former naturally being more fitted for show, and the latter for use, though the constant succession of Imperial, Royal, and Princely visitors, and the magnificent hospitality of the Emperor brought his Pavilion into even more constant service.

The list of princely personages reads like a compendium of the Almanac de Gotha, and it may be said that all the royal houses of the world, either directly or through their representatives, were the guests of the Kaiser and "the beau-" ful Empress." The Tsar, his heir, the Grand Dukes Vladimir and Nicholaus and our Crimean opponent, the plucky Sailor Prince, the Grand Duke Constantine, represented Russia. The pretty daughter of the latter, Olga, Queen of the Hellenes, was the representative of Greece. Brave stalwart Kaiser Wilhelm bearing his seventy-seven years more lightly than many another man his six lustra, was indefatigable during his stay; everywhere was the well-known blue uniform to be seen, even on the summit of the Exhibition, and it was noteworthy that the German Emperor was *bien distingué* by a total absence of orders, his breast being covered alone by medals, ranging from the campaign of 1813 to the grand cross of the Russian Order of St. George, bestowed upon him by his nephew the Tsar for bravery in the field displayed as a monarch commanding-in-chief, of this grade of this distinguished order his majesty is now the sole representative. The towering form of Fürst Bismarck at the same time was frequently to be met with, now in the silver helmet and white uniform of the Cuirassiers, and again endeavouring in vain to disguise himself in the "mufti" of simple black. The white Cuirassiers could boast of another distinguished member in the person of the Crown Prince, who with his wife, our Princess Royal, attended the opening ceremonial.

The King of the Belgians, and his brother and sister-in-law the Count

and Countess of Flanders paid at least two visits during the Exhibition to Vienna, and the neighbouring kingdom furnished its quota in the Prince of Orange and Sophie, Queen of the Netherlands; her brother King Karl of Würtemberg also presenting his pleasant well-bearded face to the Viennese lieges, accompanied by his wife, the once famous beauty, Olga, Grand Duchess of Russia and daughter of Nicholas. The burly figure of the "Re Galant'uomo," brilliant in silver lace, medals, and orders, created one of the sensations of the season, surrounded as he was by perhaps the handsomest staff of officers any crowned head can boast of, whilst the Schah dazzled all eyes with his display of brilliants, the integrity of some of which was said to be dubious. The rôle of monarchs being made complete by the King of Bavaria, who however preserved his incognito so strictly that his presence was not even suspected, until after he had taken his departure. Of "monarchs "retired from business," we had the Ex-King of Hanover, Isabella of Spain, "Henri V.," the Emperor Ferdinand, and the Arch-Duke Franz, father of the Kaiser.. The Duke of Nemours who refused a crown, that of Belgium, and his brother, the Duke of Montpensier who aspired to one, swelled the long list of princes, with Prince Charles of Roumania; the Prince de Joinville, Prince Frederick Charles, "The Red Prince" of Prussia; the Grand Dukes of Baden, and his Duchess, daughter of Kaiser Wilhelm, Oldenburg, Mecklenburg, and Saxe-Weimar, the two former being accompanied by their wives; the Dukes of Brunswick, of Saxe Altenburg, of Anhalt-Dessau, of Saxe-Coburg-Gotha, also put in an appearance, together with the Ex-Duke of Parma and his Duchess. The present King of Saxony and his Queen, attended as Crown Prince and Princess in lieu of his father King John, Queen Amalie also taking his place. There were besides, the two princes of the elder and younger branches of Reuss, (both Heinrichs, and both descendants of the Emperor Henry the Fowler,) Reuss-Schleiz and Reuss-Greiz, Prince Peter of Oldenburg, the house that has given rulers to Russia and Denmark, and even governed United Scandinavia, Wilhelm of Mecklenburg-Schwerin, the only reigning house in Europe of Sclavonic origin, styling themselves Princes of the Vandals, and claiming descent from Genseric, conqueror of Spain and Carthage, George of Saxony, Luitpold of Bavaria, Augustus of Weimar, Wilhelm of Würtemberg, young Prince Georgios of Greece (heir to the kingdom of the Hellenes, who accompanied his mother), and the Duc de Chartres. Prince Milan Obrenovic of Servia was to be seen with his tri-coloured plume of feathers, and the brave chief of a brave people, the Prince of Montenegro was a picturesque feature at the review held in honour of the Tsar. The Empress of Germany preceded the German Emperor, with whose presence finished and culminated the long list of dignities. Denmark, Sweden, and the Brazils sent their Crown Princes, and our royal family was represented by the Prince of Wales, the Duke of Edinburgh, the Duke of Connaught, the Princess Mary of Cambridge, the Duke of Teck, and the Crown Prince of Hanover, his scarlet liveries being an everyday feature in the Exhibition Park. In fine only His Holiness the Pope, the Sultan, the Khédive, the King of Portugal, and the Grand Duke of Hesse were conspicuous by their absence from what may be termed the great family meeting of sovereigns, all the other royalties furnishing at least one, some many, representatives, the bands of the garrison changing their welcomes as frequently as hosts and guests changed uniforms, from "Bodje Tsaria Haranyie" to the wild series of discords known as the Persian March, from "God save the Queen" to "Gott erhalte "Franz der Kaiser," or "Heil dir im Sieges Kranze," and the constant arrival and departure of royalty, were a constant source of excitement to the pleasure loving Wieners, as they taxed to their utmost the almost inexhaustible hospitality of the Emperor-King, nobly aided by the Arch-Dukes Rainer, Carl Ludwig, and Ludwig Victor.

Consisting of a centre and two side pavilions, all with Mansard roofs, its Corinthian columns gave to the pavilion of the Kaiser a certain nobility of aspect, whilst the gilt flag stand, with the Imperial flag that adorned its central point, crowned as it were the edifice of this bijou palace.

Within, few palaces meant to be more than the mere butterfly of a single summer, could compare in luxury. Haas, and the first firms in Vienna, strove in friendly rivalry to outdo each other in four chambers—one for the

Emperor, the Empress, the Archdukes, and Archduchesses of the Imperial family. Everywhere, gates of polished steel, marqueterie, finished as wood mosaic, chimney-pieces of black or Carrara marble, costly tapestries in lieu of paper, paintings, mirrors, satins, and velvets, sumptuous lounges and gems of ceramic ware, combined richness of effect with purity of taste; the boudoir of the Empress being unique in its walls, ceiling, and curtains of violet satin, with furniture *en suite*, all covered with exquisite lace. The Jury Pavilion, though it boasted of two stories in the centre, by its Mansard roofs and general similarity of outline, to the casual observer furnished few points of difference to its Imperial neighbour. Next in ornateness to the Russian Farm House, was the Swiss Châlet of Interlachen, with its charming balconies, open porches and verandahs, the minuteness and beauty of its wood carvings, giving one the idea of a drawing-room ornament seen through a high-power oxy-hydrogen microscope rather than a dwelling-house for mere ordinary mortals.

Those young persons who desire nothing but love in a cottage would have been suited literally "to the ground" in the charming *cottage ornée*, known indifferently as the British Commission House, or Prince's Pavilion, a one-storied oblong building of corrugated iron, standing on a terrace placed about three feet above the surrounding garden, having a verandah running round it supported on light columns, and a covered passage linking it with another corrugated iron structure called the "Exhibition Club Room." Dainty encaustic tiles, of great beauty of colour and design, supplied by Messrs. Minton and Hollins, were laid down beneath the verandah, further adorned by large green vases supplied by the same firm. The Coalbrookdale Company gave seats and railings glorious in chocolate and gold. Messrs. Jackson and Graham furnished the Prince's Room to a perfection that drew from an Imperial personage the remark, "Les Anglais sont absolument sans rivaux à l'égard "de tout ce qui concerne le confort et la propreté." The fireplace, with its wooden shelves, its plaques of green, brown, and yellow tiling, was so unique, as now to occupy a place of honour at Sandringham, Messrs. Elkington sent gems of metal art, Messrs. Cooper and Holt made the Commissioners' Room one of the cosiest nooks in the entire Exhibition, Messrs. Pavy giving it the effect of a tent with their Japanese paper hangings, and the Exhibition Club Room was remarkable as containing the only English billiard table in Vienna, the attempts made to play the English game everywhere else being such as would astonish Mr. Cook, and utterly disturb the equanimity of Mr. Bennett. Thus on its pretty green slopes, with its flag floating over a charming little English garden, the Prince's Pavilion looked no mere holiday structure, run up in a day, but a dainty dwelling, tended with care by some tasteful proprietor, combining the maximum of comfort with the minimum of show.

Mr. Thackeray has said that wherever a little colony of English is settled they make a little England of their own, with their Worcester sauce, their Crosse and Blackwell's pickles, their Durham mustard, and their Cockle's pills. All this is facile enough for those presented by Dame Fortune at their birth with a silver spoon, but not quite so easy for others to whom the capricious godmother has only given a wooden ladle, and thus the two workmen's cottages situated at the rear of the Machinery Hall, proved a perfect boon to the sixty representatives of labour who made them their home during the summer of '73. Externally they were simply corrugated iron houses, the only remarkable features being the height of the roofs, and the general trimness of their surroundings, not indeed that in a horticultural point of view their small gardens were remarkable, scarlet-runners, and cauliflowers being about the only flowers, relieved, however, by the white or lilac blossoms of the potato patch, but the practical prevailed over the poetical in the opinions of the inmates, and roses in their circumstances stood no chance against rhubarb. The centre of each cottage consisted of one long, lofty room, with a table running down the middle, and an English grate, not a stove, occupied the end. This was used both at meal-times and for a reading room, breakfasts with tea, dinners, whereat roast-beef and plum-pudding were frequent visitors, "thick teas," and suppers of beer and cheese, supplying the bodily, as a supply of English newspapers satisfied the mental appetites of the inmates. On each side were bedrooms cosily furnished, the beds having sheets and blankets in place of the

down coverlets that look so pretty, but which it takes a lifetime to properly appreciate. At the rear was the kitchen, supplemented by an admirable contrivance known as 'The British Workmen's Hotel,' a perfect kitchen on wheels. These cottages built and furnished at the expense of Sir Richard Wallace made a home for the artisan, and in their genuine comfort left no occasion for *nostalgie, heimweh*, home-sickness, call it what you will. A marquée was also provided for meals for workmen who could not be accommodated in the cottages, and when it is said the sanitary arrangements were so excellent that during a season of exceptional unhealthiness, the inmates enjoyed all the advantages of quarantine, without any of its restraints, no further proof need be given of the munificent forethought of the donor or the watchful kindness of the executive head of the English Commission. "Bradford's laundry," another specimen of corrugated iron, was a very temple of cleanliness, soap suds and steam made it their own, and washing, wringing and drying interminable piles of garments were the chronic occupations of its ministering priestesses.

The Ausstellung des K.K. Handelministerium, a building of wood framework, was a very museum of utility, its illustrations of "The Commerce of the World" forming a perfect Encyclopedia of industry, of which there is only space to note the sponge fisheries of the Mediterranean, with models showing the "spero-" nares" on the fishing grounds, with their lateen sails, their rows of sponges hung up to dry, and their groups of busy fishermen. You saw divers at work in the coral depths below, or taking headers from off their boats, and learnt how much toil was necessary to furnish, even one indispensable adjunct to the toilet. The particulars of one fishery, that on the Syrian coast will suffice for all; some 250 or 300 boats manned by from 1,200 to 1,500 men and engaged from June to October inclusive, harvest yearly from 20,000*l.* to 25,000*l.* worth of sponges. The divers who wear nothing but a net round their waists, have each a large oblong white stone fastened to a rope, and as they seize it with both hands, they descend to a depth of from 5 to 30 "brasses," about the height of an ordinary man, and plucking all the sponges within reach, remain under water from 40 to 60 seconds, when jerking the rope as a signal they ascend they deliver themselves of their spoil and recruit themselves for a fresh plunge. These models were so admirable as to need no guide, as all who ran might read the history, labours, and dangers of the sponge fishery.

A large Pavilion of the German Empire, was given to machines for Ice and Brick making, and a trophy in three stories of the Aussig on Elbe Pottery Works showed pipings of every dimension, and every possible variety of shape. The Simmering Malt and Spirits Works and the Pavilion of Baron v. Rothschild's Iron Works, were each distinguished by copper cupolas, and a wooden structure called the Additionelle Ausstellung displayed a collection bewildering in its variety. There were hats of all times, from that of Wallenstein, to those of Frederick the Great, and Kaiser Josef, the "Incroyable" of '93, the Prussian Jäger of Jena, the "dandy" of 1820, and the *petit crevé* of '73. There were weird bonnets of the beginning of the century, which made the operation of kissing our grandmothers look as if it were performed in a tunnel, and every description of feminine head gear worn by peasants of all nationalities. The piano of Beethoven and that of Schubert, the clavecin of Mozart, the plough of Kaiser Josef, with which that monarch amused himself once by "turning a clod" on what was afterwards the field of Austerlitz, and a collection of ploughs of every nation from Iceland to Ionia, from the Crimea to Cathay, from Poland to Persia, were all massed together in a museum of odds and ends, and unconsidered trifles, that many a wealthy connoisseur would give a fortune to either annex or purchase. Joh. Lubeg & Co. of Eisenbrod, Bohemia, contributed a house built wholly of slates, Paget Brothers of Vienna, a large structure of corrugated iron, the Kärntner Montan Industry in a wooden Pavilion with three cupolas, one large and two small, displayed the resources of the Czeck Kingdom, and Messrs. William Blews and Sons of Manchester, supplied an open Campanile of wood, hung with an entire peal of bells, that seemed fitted to waken the drowsy echoes of some cathedral city.

In an Exhibition like that of Vienna it was not to be supposed that the question of houses wholly indestructible by fire would be overlooked, and, in

point of fact, there were many claimants for this distinction. Messrs. Salt & Co. led the van with a Concrete House of two stories, in which walls, shelves, floors, chimney pieces, and stairs were all portions of the house itself, solid cement, and it would tax the skill of the most distinguished incendiary that ever attempted to set the Thames on fire to damage its integrity. The Deutscher Marezzo Marble Company enriched the grounds with a Garden Temple, that to all senses, save that of touch, appeared formed of the genuine material, and the Chailly House of artificial stone combined the luxury of a terrace garden with the comfort of a miniature dwelling. An open Temple with pillars supporting the porch asserted the claims of Portland cement; there were a Cement Obelisk, a Pavilion for Artificial Marbles, which were puzzling in their *vraisemblance*, a Church Porch, exhibited by Escher of Trieste, which needed the notice pointing out it was made of Portland cement to assure the visitor that it was not built of Portland stone, and the Breslau Cement House of Kobner and Kantz.

But all was not seeming, there was a column of Krapstal Marble, the Styrian Stone Company erected an elaborate trophy, and Wesserburger of Vienna, whose family, from father to son, have been stonemasons since the memory of man runneth not to the contrary, embellished the southern portion of the park with a Gothic Canopy, having a stone roof supported on marble pillars. This, save for its newness, bore a striking resemblance to the well-known tomb formed from the ruins of the Abbey of the Paraclète beneath which Abelard and Heloise, united at last, sleep their last sleep in Père la Chaise, and the resemblance would have been made complete by the addition of a sarcophagus, only the General Direction wisely thought that this would have been too strong a *memento mori*, even for the most serious-minded visitor. In this Iron Age, promulgating its new evangel of "blood and iron," when iron ships plough our seas, iron roads make their network over our land, iron bridges span our rivers, and iron pipes form iron ventricles in the hearts of our cities, it was but natural to expect that iron dwellings would assert their individuality, and, as is the nature of iron, assert it boldly. Thus every variety of edifice, from Church to Kitchen, from Workman's Cottage to Prince's Pavilion, proclaimed the work of Tubal Cain. It is not the writer's intent to speak of the great smithy of Paul Granichstaden, that though iron entered deeply into its soul, was built of wood, but of the many buildings, formed exclusively of the material, dotted over the ground. Of the Prince's Pavilion and Bradford's Laundry mention has been already made, and the Trieste and English Restauration, all built by Messrs. Hemmings, have still to be spoken of; but this seems the fittest place to describe the monster Water Tower of the "Erste Brünner Maschinen Fabrik." In height it knew no equal and but one superior, the iron Dome of the Great Rotunda (from its top you surveyed the entire Exhibition, saw the Prater and Vienna itself lying at your feet, and took in the landscape from the Leopoldsberg to the Sneeberg and the lofty chain of the Styrian Alps, from the distant Carpathians to the vine-clad Bisamberg, with the "Schöne Blaue Donau" winding through its numerous timber-clad islands), and massy though it was, its pillars with their criss-cross work bracings and myriad interlacings had a most aërial and gossamer effect.

Sweden showed that iron churches are not exclusively an English *specialité* and her iron church in its architecture did no discredit to her other buildings; an iron bridge (Witkowitz) was no mere model but in stage parlance "practicable;" Baron v. Rothschild had his iron house, and Schmidt and Keerl of Cassel a pretty iron summer house. Carl Palide of Cologne and the brothers Ab of Stuttgart displayed two garden pavilions of corrugated iron, and Paget Brothers of Vienna a dwelling-house of the same material, while the "Eisen Hof" or iron house *par excellence* was by an Hibernicism built of wood, deriving its name from being devoted solely to a display of industry in iron.

With no resemblance save in their portability, the habitations for nomad populations must now be dealt with, the marquée for English workmen has been noted before, and every restaurant had "chapels of ease" in the shape of marquées or tents pitched round the parent structure, but as there are tents and tents a special paragraph must be given to four noteworthy specimens.

Facing the pavilion of the Schah was a superb tent of a Persian general, a

perfect canvas house to contain the chief, his staff, and attendants. Like nothing so much as the marquées limned by Holbein when he pictured the Field of the Cloth of Gold, it had its canopied entrance, and as you passed the threshold you found a tent within a tent, the outer being composed of canvas, richly decorated, the inner for the use of the general, being made entirely of silk. This inner tent comprised three rooms, all richly carpeted, the supporting sticks or pillars were elaborately painted, and there all attempt at ornament ended, the followers had but a canvas roof and a sanded floor. In an angle of the Khédive's palace was the tent of a Bedouin chief formed of camel's hair, and though that of a Bedouin of the Red Sea does not come within the sphere of this report, being in the Industrial Palace, a line must, however, be devoted to its strange oblong shape, its walls of criss-cross sticks, and its inner lining of skins. Khiva, the Kirghizes, and General Kaufmann attracted much of the world's attention last year, and the "kibitcha" of a Kirghiz family was not without observers in the Prater. Dome-shaped, it resembled nothing so much as a monster bee-hive, its covering of thick felt being supported on large wooden hoops. For a nation of nomads nothing could be more complete, the house, walls and roof, is carried by one camel; when the camping ground is reached, the camel kneels, two women set to work, unload him, and erect the "kibitcha." The walls are formed of four pieces of trellis work, about six feet long, slightly curved in the centre, these fold into one another as compactly as the leaves of a screen, and when opened out complete the circle leaving a space for the entrance. The roof is merely some thirty half-hoops which loop into a central hoop some three feet in diameter, the hole serving as an exit for the smoke. Set these up, spread the felt and your house is built, labour power, two women, time, a quarter of an hour, strength, sufficient to resist the greatest storm of either wind or rain. So that taking all things into consideration, the Kirghiz "kibitcha" set up as it is in the desert is a proof that everything "built on sand" is not of necessity unstable. A Kirghiz village or encampment, formed of from four to twelve of these "kibitchas" is called an *aul*. Within, it would appear that luxury even pervades the desert; there were soft cushions, dainty rugs, and an elaborate display of brass culinary utensils. Models of a Kirghiz family sat around a pot evidently, from the placid expression of their countenances, containing some choice preparation, and as the lady of the house, or rather "kibitcha," composed the "menu," her soul, like that of *chefs* of our day, was sublimated by the strains of a lute played by a bard who evidently sang as if "no song, no "supper," was a golden rule of Kirghiz hospitality.

Close to the latter was a tent given to a display of Samoede life, there was a Samoede tent, bell-shaped, formed of reindeer skins stitched with reindeer sinews, at the door was a Samoede matron dressed in reindeer coat and trowsers, nursing a Samoede *papoose* swaddled up in the same material, which also furnished the coat and "breeks" of the juvenile Samoede who stood by her side; two Samoede fathers drove the sledges harnessed by reindeers, one team having their summer, the other their winter coat, a huge white bear bid you welcome, and a white whale sped the parting guest, there were skins of the white and black fox, of the sea lion and the seal, of the ermine and the white bear, specimens of many woods, and most interesting of all, some fine samples of bituminous coal that would delight geologists and that may yet attract the attention of some limited liability companies. Thus we have seen the materials used for tents were many, and there only remains to specify the square india-rubber tent, of the Rhine India-Rubber Works, Cologne. The other buildings must be rapidly enumerated before proceeding to the great question of the Restaurations, noting the Pavilion of the Austrian "Sauer Quelle" where mineral waters from every part of the empire were daily dispensed; the Pavilion of the Photographic Institution, for the sale of views of the Exhibition, originally a Swedish construction; the Shed for Railway Carriages of Chevalier Chulis & Co., 41 Quai de Grenelle, Paris, containing one first-class saloon carriage and two travelling post offices, one with letter box for posting letters at the last moment, an admirable idea; a Shed holding a corrugated iron life-boat; the Pavilions of the Russian Iron Works, and of the Industrial Society of Prague; the Pavilion of Steffens, for machinery; the Pavilion of

Aussig, near Komotau, Bohemia; that of the K. K. Priv. Actien Gesselschaft Innerberger Haupt-Gewerkschule, an institution for training future captains of mines, who are thus taught a dangerous and difficult duty in a methodical and scientific manner, and who wear it may be here said one of the most picturesque uniforms in the entire Austrian service; the Pavilion of the Steirmark Iron Works; that of R. Ph. Waagner of Vienna, built of wood richly gilt and decorated, with a handsome oxydised iron porch surmounted by horses' heads and showing within an elaborate display of stable fittings; the Tent of the Bazar de Paris, where small balloons filled with gas, were daily distributed; the Pavilion of Heller of Berne, a perfect "cave of harmony," containing from an organ imitating a full band to chairs that played "See the conquering hero comes," as you sat down, and bottles that gave "a deep, deep draught of the red Rhine wine," tune and tipple combined (if it be not profanation to call Johannisberg or its ruddy brethren by such a name); the Wooden House of J. W. Jacobson and Co. of Friedrickstadt, Norway, where, Dr. Johnson tells us, "destined for a barren strand, a pretty fortress and an unknown hand," Charles the Twelfth "left a name at which the world grew "pale, to point a moral or adorn a tale"; the Pavilion of the Savings Banks; the Kiosk of the Sudbahn; and a large open Shed containing a number of railway carriages, wagons, sea and life-boats.

There were in addition, a plain weather-board construction filled with the number of ingenious educational appliances that might be expected from our Transatlantic cousins, known as the American School House, and two similar buildings belonging to Portugal and the German Empire.

Joh. Schuberth exhibited an entire colony of wooden houses, some large as an ordinary cottage, others small as a sentry box, and two garden houses built altogether of criss-cross open work; another manufacturer displayed, an octagonal house, built completely of wooden laths in which the walls were so constructed as to roll up like blinds; and scattered in every direction were garden houses in every possible variety of design, and kiosks for the sale of fans, fruits, flowers, tickets for theatres, for the exhibition of gas apparatus, or serving as telegraph offices, one being remarkable for its grass covered roof, the office of Messrs. Aveling and Porter of Rochester.

Its immediate neighbour, a plain corrugated Iron House, was however the object of many anxious inquiries from English-speaking tourists, for there Messrs. Thomas Cook and Son distributed, for an honorarium, those magic coupons that save the traveller time, trouble and thought, inquiries on every possible subject, and every probable route were made of and answered by Mr. Osswald, and a reading-room filled with English and American newspapers proved a literary oasis in a desert of unknown tongues. In close vicinity to the Jury Pavilion was a Library rich in what may be termed the literature of the Exhibition, the most polyglot of collections in works both ephemeral and lasting.

Sight-seeing is naturally an exhausting operation and after the prolonged mental effort necessary to take in and digest the myriad wonders contained within the ring fence of the Exhibition, nature herself reiterated the cry of "il faut consommer" with as much persistence as a *garçon* in the now defunct Café des Aveugles at Paris. The only difficulty indeed to simple-minded folk was to make up their minds before making up their bodies, and to know where they might best repair their wasted tissues. There were restaurants—English, where meritorious if not always successful efforts were made to at least spell the names of English dishes; American, where clam-chowder and pumpkin pie were procurable; Italian, Swedish, Swiss, and Russian; "Les "Trois Frères Provençaux," like a phœnix, resuscitated its old Palais Royal glories; Sacher upheld the credit and the tariff of his famous restaurant, and every variety of German viand was obtainable at numberless *restaurations*, from *bock hähnl* to *Kalbsbraten* and *Kolasch* in meats, or *fogasch, sterlet* and *Danube carp* in fishes down to the simple Ementhaler Käse and garlic-scented Salami. In fluids the field of choice was even still wider, you could procure anything you desired, from a bottle of Guinness's stout to a cup of Russian tea, from an ice cream soda to a glass of Amontillado, every variety of vintage from Monte Pulciano to Ruster, from generous Chambertin to acid Styrian, whereas of the variety of beers there was literally no end.

Entering at the Elisabeth Avenue the first building that caught the eye on the right hand was the Hungarian Csarda, picturesquely perched on the summit of a green mound, itself as picturesque as its site. Its thatched roof and Norman arched porches gave it a unique appearance. At the side facing the avenue projected a square porch supported by square pillars, whose balustrade was as artistic in effect as it was simple in construction, being formed merely of open brickwork. Ascending the slope you came on the terrace where a Zigeuner band with violins, zither and clarionet beguiled, with wild Hungarian melodies, the time occupied in consuming flasks of Schomlauer, Erlauer, or Adelsberger, Ruster or even princely Tokay. Around you on every side were seated Hungarian peasants in the costume so well known through our hussars, or cattle herdsmen "Gulyàs," and horse keepers "Czikos," in elaborately embroidered sheepskin *bèkes*, and half hours passed more pleasantly at but few places in the grounds than the moments spent at the Hungarian Csarda. Immediately beside were the two Pilsner Bier Halles, that of the "Actien "Brauerei," and the "Pilsner bürgerlichen Bräuhauses; both two storied, the former built of stucco, the lower story projecting so as to form an upper terrace all round the building; the latter of wood, with a wide verandah occupying three sides. Around both these houses were tables without count, and from 12 till 2 the visitor considered himself fortunate to obtain a seat either within or without, while worried waiters ran to and fro, *bier-trägers* bearing as many as a dozen full glasses in their hands were ubiquitous, a storm of *bittes*, *komme-gleichs*, and *augenblicklichs* met your appeals for food, and no better school could anywhere be found for exercising the greatest of all virtues, patience. On the left was the Chicago Restaurant, one storied and over shadowed by fine old trees remnants of the primeval Prater. Here the mysteries of American cookery might be practically studied; the well meaning effort to impart culinary knowledge, however, can hardly have been successful as before the close of the Exhibition, the business changed hands passing over to the well known brewer Dreher. Two small Kiosks (Piel) did a business far surpassing that of many more pretentious concerns, supplying wine, coffee, or cognac to wash down the *gaufres* that all day long were turned out piping hot to expectant crowds.

A wooden kiosk for the sale of Hungarian wines kept by Ignacz Flandorffer, a French Liquor Buffet, for the sale of brandies and wines, and one wholly given up to Champagne, nigh at hand were also well patronized; and beside the Spanish Additional Exhibition, Juan Morphy of Cadiz erected his kiosk where admirers of sherry, rejoicing to find good wines, did not grumble at the price, 80 kreutzers a glass. The American speculations to provide food did not pay, possibly from the rarity of American visitors, for not only did the Chicago Restaurant change hands, but also, the American Bar in the Elisabeth Avenue and the American Restaurant near the Machinery Hall. In the first, afterwards the Bier Halle of Elbschloss and Leitmeritzer, the great problem of air without draught was fully solved, the lower story open all round supporting an upper one on pillars, that again bearing the roof; there were no walls, no windows, but thorough shade and ventilation. The American Restaurant, subsequently that of Abel, Moser and Bosse, was built entirely of wood and presented no striking feature to attract attention. The Liesinger Bier Halle consisted of a large central *salle à manger* of one story, and two wings each of three stories, and in this instance, the wisdom of taking time by the forelock was fully exemplified; for built long before the Industrial Palace itself, the business done before the opening was such as to recoup the proprietors, both for the building and rent during the entire display, leaving a margin of profit greater than many businesses obtain for the labours of a lifetime.

Singularly graceful and light in construction, the Swiss Buffet was an effort of genius on the part of its architect; built of wood, brightly painted, with four projecting porches, a centre campanile and verandah running all round, it would be difficult to decide the nationality of its architecture, the shoes that supported its roof were decidedly Moresque but there all attempt to describe it must end, suffice it to say that Swiss maidens in their piquante snowy

chemisettes and black bodices, ministered ices and coffee all day long, and that whatever the attraction the châlet, the *Kellnerinnen*, or the coffee, it was always crowded. The Swedish Restaurant of Theodor Blanche of Stockholm has been already described, and it may be only incidentally mentioned that the Swedish punch compounded therein was considered one of the successes of 1873. The Restaurant of the "Trois Frères" gastronomically was everything, architecturally nothing, being simply wood and canvas looped up to form curtains, one great advantage it possessed being that from one of the covered ways leading directly to it, one could pass under shelter from any part of the Exhibition. Attached was a wooden house, the office and store room of the well known firm of Tampier Frères of Bordeaux. The Russian Restaurant asserted its nationality within and without in every possible manner, in its quaint Sclavonic architecture, its waiters in caftans, pink, red, or blue, and black velvet knickerbockers, and its viands and fluids including the indispensable caviar and vodka, whilst the bright *samovar* supplied tea to be drunk *à la Russe* "with one slice of lemon in the tumbler." The full merit of decoration was amply shown in the Italian Restauration of Natale Biffi of Milan. The building itself, though of two stories, projecting porch and verandahs, would have been nothing with its simple whitewashed walls, but with trophies of flags and innumerable shields of all the cities in Italy, marking its lines and angles, it was as bright and cheerful as even the Swiss Buffet itself, and the annexed wine house, *osteria, trattoria*, call it what one will, was a notable feature of the year, there being no waiters but pretty *contadinas*, whose costumes fitted them to wait for artists at the steps of the Trinita de' Monti, or come on at Covent Garden in a chorus of Masaniello or Fra Diavolo. Near the Kirghiz hut was a small Kiosk for the sale of Wildpret Bouillon, where for ten kreutzers one might taste soups originally prepared on the borders of the White Sea. And now plunging into a genuine bit of forest scenery one came on a genuine Styrian house built entirely of wood, half hidden in greenery, it had its exterior staircase leading to a balcony and upper story, the pent-house roof covered with shingles sloping nearly to the ground. In front were rough tables and benches round which Styrian damsels, with short red *jupons* and snowy kerchiefs tied round their hair incessantly hovered bearing bottles of wine for thirsty souls, whilst some Styrian mountaineers produced charming strains from an extraordinary melange of instruments, violins, zithers, and rock and wood harmonicons, the sweetness of the tones produced from the two latter being simply marvellous. On the hottest day the shade here was perfect, and though the house was hidden in the depths of the wood few wine-houses were better known; for the cunning proprietor had taken the precaution of placing life-sized figures of Styrian peasants admirably painted at every entrance to the wood. Also bowered in trees was a quaint tent covered with painted figures of Fenimore Cooper's Indians performing deeds of dering-do, scalping enemies, and all the other amenities of these children of nature, whom Artemus Ward designates as "pison," this was known as the Wigwam, and the local colour of the scene was fully carried out in the eyes of Continentals by the employment of exclusively black waiters dressed in spotlessly white suits. Within the Wigwam a distinguished professor from New York compounded seductive mixtures with peculiar names, from the unsophisticated simplicity of a "whisky skin" to the high art of a "Catawba cobbler," while "slings," "smashes," and "juleps," were fragrant with mint and tempting as ice and sugar could make them. The Café Turc served as a foil, there, fine featured Greeks in fez and baggy trousers brought you Turkish coffee, half of it grounds, in tiny *zarfs* and kindled your tchibouque or nargileh with live charcoal. The Cercle Oriental was not so exclusive in fluids, all being obtainable and the dishes excellent, the waitresses being costumed as Bayadères, and as a matter of course utterly unlike their Moslem sisters. The Trieste and English Restaurants were simply corrugated iron buildings raised some three feet above the ground on a terrace with verandahs running round them, and having no particular features save that in the latter a dock wine glass full of bitter beer was procurable for the small sum of 30 kreutzers or sixpence.

Over the Heustadl Wasser, were the Kriau Restaurant, kept by the well-known Vienna chef Sacher, the Tiroler Bier Halle, with waitresses in high

hats, ornamented with either cock's plumes or flowers, and several small beer-houses whose bill of fare, besides beer, included all kinds of Austrian comestibles, including *Sauregurkenzeit*, cucumbers pickled in brine, and suggestive of cholera, evil smelling Limburger cheese, *Liptauer garnirt*, and every variety of salami and sausage. Near the Austrian Agricultural Hall was a plain wooden shed ascended by steps, and divided within into a series of booths; this, the Kost-Halle was noted as a Cosmopolitan bazaar for the sale of liquors, one booth was occupied by "La Grande Marque" Cognac Company; its neighbour devoted itself to Maraschino de Zara, a Dalmatian lady presiding in full national costume, a fortune of sequins, real or sham, being hung around her; opposite a Dutch damsel from Friesland, with a gold head-dress having two bosses at the side and surmounted by a lace cap, ministered Schiedam; Champagne, Dunville's Irish Whisky, Curaçoa, Kirchwasser, Eau de Dantzic, and all the innumerable tribes of liquors were all obtainable at separate stands superintended by girls in every imaginable costume, and all through the day an endless stream of visitors poured in to see if they did not remain to drink. The Kärntner Restauration (Silberberg Company) a wooden building of two stories with double story porch and verandah, was another feature from the excellence of the beer and the attractions of the *Kellnerinnen*, whose immense snow white ruffs, high kilted dresses and tall high-heeled laced-up boots were picturesque to a degree. There were also wooden Bier Halles, such the St. Marxer Märzen Quelle, kept by Pamperl & Co. the Restaurant du Nord, the Hamburger Restauration of two stories (J. & J. Luckmann) and that of Willsvouseder and Grubin at the rear of the Machinery Hall, all frequented by the lower classes of visitors, and differing in nothing from the Bier Halles in the Würstel Prater; but the subject as well as the list of the Bier Halles and Restaurations is now exhausted and it cannot be hard to guess from it that visitors whether with slender or full purses could find no difficulty whatever in appeasing their appetites. Amongst a nation of smokers it would have been impossible to have omitted the Tabac Trafik, and numbers of these were therefore dotted about in every direction to furnish the indispensable cigar, the principal being that belonging to the Specialitäten-Trafik in the Graben, and it needed the sign to divine that it was a tobacco shop, its burnished copper dome, arched and laticed windows, and arasbesque decorations bearing more resemblance to a small mosque or mausoleum erected over some defunct *Hadji*. The supply of fluids, did not, however, cease with beers and wines nor the solids with meats; Messrs. Dows, Clark & Co. in a corrugated iron building, manufactured delicious aërated waters to supply their five soda water kiosks, pretty iron constructions with cupola roofs; Karl Heilfinger had his Machine Bakery for the coarser kinds of bread; and Roman Uhl, the Court Baker, a large factory to meet the demands made on his handsome shop facing the Water Tower where *Mehlspeisen* of every description tickled the palates of children young and old. The long array of buildings has now like all things mundane come to an end, but still a word must be said of a construction which was neither Pavilion, Bier-Halle, Café or Restauration, but only a tree built up in sections, the enormous "Araucaria" or "Monkey-puzzle," so called from the spikes with which it is covered frustrating the climbing efforts of "our poor relations," which with the Brazilian flag at its summit towered erect for some two hundred feet near the Khédive's palace.

Passing from the descriptive to the statistical, it may be interesting to summarise the space occupied and the number of buildings. Without in the former instance going into decimal parts, it will be sufficient to say that the Industrial Palace covered, including all courts and "hofs" nearly 43 acres, that the extent of the park enclosed by palings was 286, and inclusive of the ground occupied by the horse and cattle shows no less than 573 acres, and that the estimated cost of the buildings to the General Direction was nearly sixteen millions of florins, which, allowing for the depreciation in paper currency, would be more than one and a half million pounds sterling, leaving all subsequent expenses to be paid. The number of buildings large and small on the grounds may be reckoned at, in round numbers, about four hundred constructed of every possible material and in every conceivable variety of style. Of these America furnished one brick, three wooden buildings, and the canvas Wig-

wam; Great Britain, one structure of brick, eight of corrugated iron, one of wood and glass, five kiosks of iron, ten wooden houses, one concrete, and a marquée. France, six brick buildings, one iron, one cement, six wooden, and a number of canvas erections; Sweden and Norway, 11 wooden houses and an iron church; Spain, one house of wood and plaster, and a kiosk of wood; Portugal and Monaco, each a wooden house; Switzerland, one brick and four wooden structures; Italy, five wooden, two iron houses and the model of the Mont Cenis Tunnel; Russia, seven wooden, one iron house, and the "Kibitcha"; Belgium, one brick and one wooden; and Egypt, the Palace of the Khédive. To Turkey must be assigned 10 wooden houses and the Sultan's Treasury; to Morocco, one house; to Persia, the Schah's Pavilion and a marquée; and Japan gave her Temple Garden. The German Empire had three brick buildings, one tent, 13 wooden houses, two of cement, and one of metal, whilst Austria herself supplied 19 houses of wood and plaster, eight of cement, seven of brick, one of stone, 25 of wood, one of slate, 10 of iron, and six tents, besides watch-houses, telegraph offices, Wechselstubes, Herren and Damen Toilettes, Custom Houses, Barracks, covered ways, and all the many buildings used for the purposes of the General Direction, a total, large and small, amounting to nearly 400.

It was indeed a cosmopolite city for a cosmopolite gathering, for princes and peasants, for dwellers in the mountains or on the plains, for those who pass their lives "in cities pent," as for the free denizens of the desert; and whether seen in the broad noon day when Occidental and Oriental jostled one another in every masquerade of national costume, or on that never-to-be-forgotten night the Weltausstellung Fest, when every Kiosk and Bier Halle blazed with light and the entire scene was an Austrian Feast of Lanterns, the grounds of the Vienna Exhibition were a glorious success, and though future International displays may and doubtless will surpass both the Exhibition itself and each other, yet as civilization rounds off all angles, and the iron horse rapidly sweeps away before its onward path the costumes and the customs of isolated peoples, it may well be doubted whether the practical and the picturesque, the modern and the mediæval, the East and the West will ever again mingle in one harmonious whole, with such equal aid from art and nature as on the Prater of 1873, in The Buildings in the Park.

HUGH WILLOUGHBY SWENY.

LONDON, 1874.

THE EXHIBITS AND BUFFETS IN THE ROTUNDA.

Although only a reduced and modified version of the original idea, the Great Rotunda was undoubtedly the architectural feature of the Vienna Industrial Palace. The first scheme of its architect, Mr. Scott Russell, the worthy coadjutor of Mr. Brunel, was Brobdingnagian, being no less than the construction of a dome 800 feet in diameter; this, however, would have involved so great an expenditure of time and money as to render it impracticable, though his success, on a reduced scale, has proved it not impossible. However, its actual diameter, 345 feet, was sufficiently grandiose to astonish the uninitiated and convert the experts in engineering science, whilst the method of construction, building from above, was as unique in practice as the conception was bold in theory. As events march rapidly in our days, and one wonder pushes another out of memory, it may be well to set down here a relative comparison of the diameters of the great domes of the world, and the greatest spans covered by any roof: St. Paul's Cathedral, 110 feet; St. Peter's, 152 feet; the domes of the great Exhibition of 1862, 159 feet each; the roof of St. Pancras Station, 240 feet; and the Vienna dome, 345 feet. An appreciation of these figures will be best gained by taking a familiar example, the superb Reading-room of the British Museum; the walls of this building are 30 feet in height, from whence springs the dome 140 feet in diameter, with a total height of 100 feet; whereas the girders of the Vienna Cupola start from a ring 80 feet above the ground, giving a total height of 250 feet. It was indeed an Imperial Hall worthy of the mightiest days of Roman power, and the original intention of retaining it intact as the theatre of great displays was beyond all doubt, the correct one, as first ideas frequently are. Thus it was proposed by erecting tiers of seats to transform the interior into a mighty amphitheatre, where, indeed, no cries of "Christianos ad leones" should be heard, no gladiator, *secutor* or *retiarius* should be doomed to death, *pollice verso* of a brutal mob, but where mighty congresses of "the parliament of man" should plan and plot for the advancement of civilization, and where the sovereignty of labour should receive its reward of "the sovereignty of blood. Though architecturally, this remained but an idea in one man's brain, yet the effect of the masses who filled its area on the Inaugural Fête was a convincing proof that even as a mere vehicle for spectacle its ulterior usage was a lamentable mistake.

It was then proposed that a large orchestra should be erected in its centre, where the fountain of Antoine Durenne subsequently stood, and that visitors should either rest or promenade to the strains of Strauss or Langenbach; the final proposal being, that each country should furnish a trophy of its choicest exhibits, and that in the midst of greenery and sculpture, the essence of all the World had to show of beauty or novelty should be enshrined in a fitting Temple of Labour. All this is unwritten history, the "might have been" that ever presents itself; none of these schemes were adopted, and what the reality was all visitors must remember; how chance seemed to reign supreme, how incongruities were forced into strange companionship, and how extremes met and even jostled one another can best be told by the mere recital of the Exhibits in the Rotunda.

BUFFETS IN ROTUNDA.

AND. ERLICH, Rothenthurmstrasse.
GEBRÜDER STÖLLWERK, of Cologne, Chocolate Buffet.
GEBRÜDER STÖLLWERK, large Buffet.
GRAND BUFFET, "SACHER."
BOEHM AND WIEDL, American Buffet.
E. SCHMIDT, Michaelerplatz.
A. GERSTNER, 5, Kärnthnerstrasse.
F. SACHER.

OBJECTS NOT UNDER GROUPS IN ROTUNDA.

COLOSSAL BUST of KAISER KÖNIG FRANZ JOSEF, opposite South Entrance.
TROPHY OF GIFTS to the (late) KING JOHN of SAXONY and QUEEN, on the occasion of their "Golden Wedding."
LARGE FOUNTAIN, "ANTOINE DURENNE," also in Group.
CATALOGUE STAND, PLANS, ELEVATIONS, and SECTIONS of ATHENÆUM, by General Direction.

EXHIBITS IN ROTUNDA AND HALF GALLERY UNDER COUNTRIES.

Abbreviations.—R. Rotunda. H. G. Half Gallery.

GREAT BRITAIN.

H. G. EUGÉNE RIMMEL, LONDON.—Perfumery and toilet objects.
H. G. ROWLAND and SON, LONDON.—Perfumery and toilet objects.
R. PIESSE and LUBIN, LONDON.—Perfumery and toilet objects.
R. PRICE'S CANDLE CO., LONDON.—Glycerine and stearine.
H. G. JACOBY MORITZ and CO., NOTTINGHAM.—Lace curtains.
H. G. LOUIS BEHRENS, MANCHESTER.—Velvets.
H. G. PEEL, BROTHERS and CO., BRADFORD.—Woollen fabrics.
R. J. and C. WATERS and CO., MANCHESTER.—Sewing cottons.
R. COLLECTIVE EXHIBITION of MACCLESFIELD.—Exhibitors—Brocklehurst and Sons, Potts, Wright and Co., Critchley, Brinsley and Co. W. W. Cornes and Co., Samuel Pearson and Co., James Mellor, Josiah Smale and Co., J. O. Nicholson, and William Smale, London and Nottingham.—Silk trophy.
R. COPESTAKE, MOORE, CRAMPTON and CO., LONDON and NOTTINGHAM.—Lace.
R. KIRBY, BEARD and CO., LONDON.—Needles.
R. SPEAR and JACKSON, SHEFFIELD.—Machine saws and tools.
H. G. BATTAM, HEYWOOD and HANKS, LONDON.—Ebon and gilt trophy, with table, chairs and carpet, designed by Dr. Dresser.
H. G. GILLOW and CO., LONDON.—Cabinets, mediæval designs, and with them bronze clocks and candelebras, from Howell and James.
H. G. SANGSTER and CO., LONDON.—Umbrellas and Sunshades.
H. G. C. F. REIN and SONS, LONDON.—Acoustic and surgical instruments.
H. G. M. PILLISCHER, LONDON.—Optical instruments.
H. G. W. DENNY and BROTHERS, DUMBARTON.—Model of Spanish Royal Mail Steamer "Lopez."
R. LAIRD, BROTHERS, BIRKENHEAD.—Models of ships.
R. PALMER'S SHIPBUILDING and IRON CO., JARROW ON THE TYNE.—Ship models.

FRANCE.

R. THIEBAUT et FILS, PARIS.—Iron and steel ware.
R. BÉCHET and Co., PARIS.—Copper ware.
R. ANTOINE DURENNE, SOMMEVOIRE, HAUTE MARNE.—Metal trophy.
R. ANTOINE DURENNE, SOMMEVOIRE, HAUTE MARNE.—Large fountain, centre of Rotunda.
R. P. L. HUGEDÉ, PARIS.—Glass and enamel letters.

BELGIUM.

R. JULES KÖNIGSWERTHER, BRUSSELS.—Leather goods.
R. SOCIÉTÉ ANONYME, LOOKING and PLATE GLASS WORKS, of HENNEGAU ROUX, near CHARLEROI.—Three large mirrors.
H. G. CLAUDE LELORRAIN, BRUSSELS. — Fancy toilets and articles in *porcelain.*
H. G. COLLECTIVE EXHIBITION of LIEGE GUNMAKERS.—D'Ancion et Fils, Beuret Frères, Dresse, Lalaux et Cie., Falisse et Trapmann, August Francotte, Gulickers.—Machinay, Ed. Malherbe.—Manufacture d'armes de Guerre.—G. Mardaut, Pirlot Frères, Renkin et Cie.—Rifles, fowling pieces, and arms of precision.
R. LÉON SUYS, BRUSSELS.—Model of Brussels Bourse.
H. G. ARMAND LOUIS JOSEPH BOURDON DE BRUYNE, GHENT.—Altar and decoration.
R. COZER FRÈRES, LOUVAIN.—Pulpit.

SWEDEN.

R. CHS. ASPELIN, FAGERSTA, WESTANFERS.—Iron and Steel trophy and Ores.
R. H. GAHN, UPSALA.—Chemicals.
R. STOCKHOLM.
H. G. JÖNKÖPING. } Match Factory Trophies.
R. CARL EKMAN and H. DE MARÉ, FINSPONG.—Armour plates.

NORWAY.

R. KONIGSBERG SILVER MINES.—Specimens of silver ores.
R. J. TOSTRUP, CHRISTIANA.—Filigree work.

DENMARK.

H. G. V. CHRISTESEN, COPENHAGEN.—Gold and silver work.
H. G. J. G. LUND, COPENHAGEN.—Drawing-room furniture.
H. G. S. and A. JENSEN
H. G. „ „ } COPENHAGEN.—Furniture.
H. G. BING and GRONDAHL, COPENHAGEN.—Porcelain.
R. KING'S PORCELAIN FACTORY, COPENHAGEN.—Porcelain.
H. G. H. DEMANT, ODENSE.—Sewing machine.
H. G. MALLING-HANSEN, COPENHAGEN.—Writing machines.
H. G. MALLING-HANSEN and JÖRGENSEN, COPENHAGEN.—Writing machines
H. G. PROFESSOR E. JÜRGER, COPENHAGEN.—Mathematical machines.
H. G. H. E. HOLST, COPENHAGEN.—Cocks and optical instruments.

SWITZERLAND.

R. EIDGEN, STABSBUREAU, BERNE.—Topographical charts.
R. ROBERT DORER.—National monument.
R. FERDINAND SCHLÖTH.—Model of St. James' Column at Bâle.

ITALY.

R. J. KUBLI, CÆSAR MARCHINI, FIESOLE, FLORENCE.—Straw industry.
H. G. LUIGI UDINA, VENICE.—Bronze figures.
H. G. JACOB ROSETTI, BRESCIA.—Photographs.
H. G. ANTONIO SORGOTTO, VENICE.—Photographs.
H. G. } KARL NAJA, VENICE.—Photographs.
H. G. }
H. G. VIANELLO, BROTHERS, VENICE.—Photographs.
R. and H. G. } CONSTANTINO PANIDANI.—Two statues, marble.
R. and H. G. } ALESSANDRO PUTTINALI.—Two statues, marble.
R. MENGONI, MILAN.—Model of Galleria Vittorio Emmanuele.

GERMAN EMPIRE.

H. G. WILHELM REIGER, FRANKFORT.—Perfumery and soap.
H. G. F. JOBST, STUTTGART.—Pharmaceuticals.
H. G. GERMAN EMPIRE UNITED TROPHY OF MINERAL OIL WORKS AND PRODUCTS.—Mineral oils.
H. G. SAINT GOBAIN MANHEIM CO., TROPHY.—Chemicals.
H. G. ROSSNER SCHNEIDER and Co., 3, ZEITZ. SAXONY.—Parafin oils obelisk.
H. G. JOHANN MARIA FARINA, opposite JULICHS PLATZ, COLOGNE.—Eau de Cologne.
H. G. SCHIMMEL and Co., LEIPZIG.—Flavouring essences.
H. G. MARIA CLEMENTINE MARTIN.—Eau de Cologne.
H. G. BROTHERS BEST, OSHOFEN, HESSE.—Starch.
R. FRANZ MARIA FARINA, COLOGNE. } Eau de Cologne.
R. JOHANN MARIA FARINA, COLOGNE. }
H. G. GERMAN EMPIRE UNITY MINERAL OIL.—Chemical trophy.
R. WILHELM VOGEL, CHEMNITZ, SAXONY.—Furniture and woven fabrics.
H. G. EDWARD OPPERMANN, HANOVER; GEBRÜDER BUHLMANN, BERLIN; FRANZ EBEL, BERLIN; R. SCHÄRFF, BRIGG, SILESIA; GEORG und R. EBERMAYER, HAMBURG; GUTKIND und BAB, BERLIN.—Woollen trophy, textiles.
H. G. PRÖLSS SEN and SON, DRESDEN.—Damask and linen.
H. G. BERKENKAMP, D. and Co., BARMENS, RHINE; REINHOLD F. BACHER WOLFF, BERLIN; LEOPOLD DANN and Co., FRANKFORT A. D. M.; J. S. DILBERN, ALTONA.—Textiles.
H. G. KARL DÜRFELD, CHEMNITZ.—Furniture stuff.
H. G. JUHR und HEISE, CHEMNITZ.—Cloths.
H. G. N. REICHENHEIM and SON, BERLIN.—Woollens.
H. G. J. v. HECKEL, MUNICH.—Artificial flowers.
H. G. JOHANN WÜLFING and SON, LENNEP, RHINE.—Woollens.
H. G. COLLECTIVE EXHIBITION of SAXON ARTIFICIAL FLOWERS, DRESDEN.—Artificial flowers.
H. G. A. HERZOG and Co., LOGELBACH.—Woollens.
H. G. L. LEUSCHNER, GLAUCHAU, SAXONY.—Woollens.
H. G. KARL DÜRFELD, CHEMNITZ.—Furniture staff.
H. G. ERBEN BOLSIUS, BERLIN.—Flowers and feathers.
R. MACHINE WORKS ZU LINDEN, LINDEN, HANOVER.—Woollens
H. G. GOTTFRIED MERZBACHER, MUNICH.—Furs.
R. F. WITZLEBEN, LEIPZIG.—Furs.
R. G. FRIEDEMANN, LEIPZIG.—Trophy, stuffed animals.
R. CORNELIUS HEYL, WORMS, HESSE.—Leather.
R. MICHEL MAYER and DENNIGER, WORMS.—Leather.
R. DÜRR und REINHARDT, HESSE.—Leather.
R. D. VOLLGOLD and SON, BERLIN.—Silver ware.
H. G. S. ELSTER, BERLIN.—Bronze candelabra.

H. G. Sy and Wagner, Berlin.—Silver ware.
H. G. Gustav Görsch and A. Schneider, Berlin.—Armour.
R. H. A. Jürst and Co., Berlin.—Silver ware.
R. Collective Exhibition, Bavarian Goldsmiths: J. C. Biberbach, Georg A. Beckh, Wolffgang Ehrmann, Supf and Klinger, Jacob Gilardi, Friedrich Nüchterlein, Schmelz and Lorsch, Conrad Kühler, J. Conradty, Paul Linz, Carl Hörmann, G. F. Fischer, Eiermann and Tabor, J. Brandeis, sen., E. Kuhn, Johann Lägel, all of Nürnberg and Fürth.
H. G. Martin Mayer, Mainz, Hesse.—Jewellery and silver ware.
H. G. Emil Richter, Breslau.—Weapons.
H. G. Johann Stroblberger, Munich.—Hunting weapons.
H. G. H. Leue und Timpe, Berlin.—Hunting weapons.
H. G. A. F. W. Timmer, Coblenz.—Hunting weapons.
H. G. C. A. Fischer and Son, Lubeck.—Hunting weapons.
H. G. Nicolaus von Dreyse, Sömmerda, Saxony.—Hunting weapons.
H. G. Pistor und Kost, Schmal-Kalden, Hesse Nassau.—Hunting weapons.
H. G. H. Barella, Berlin.—Hunting weapons.
H. G. Leopold Bruck, Berlin.—Electro (China silber) ware.
H. G. C. A. Münchmayer and Co.—Brunswick.—Electro (China silber) ware.
H. G. A. Ritter and Co., Esslingen, Württemburg.—Electro (China silber) ware.
H. G. Gerhardi and Co., Lüdenscheid, Westphalia.—Electro (China silber) ware.
H. G. Basse und Fischer, Lüdenscheid, Westphalia.—Electro (China silber) ware.
H. G. Henniger and Co., Berlin.—Electro (China silber) ware.
H. G. Clarfeld and Springmeyer, Aix la Chapelle.—Cutlery.
H. G. C. Maur, Hamburg.—Bookcase.
H. G. Leo Meyer, Dresden.—Buffets.
H. G. A. Türpe, Dresden.—Buffets.
H. G. Degelbeck, Nürnberg.—Buffets.
H. G. O. B. Friedrich, Dresden.—Furniture.
H. G. Depont.—Furniture.
H. G. C. A. Fischer, Hamburg.—Furniture.
H. G. F. Wirth's Sohne, Stuttgart.—Furniture.
H. G. Georg Lang, Oberammergau, Bavaria.—Furniture.
H. G. G. Udluft Hartmann and Co., Dresden.—Furniture.
H. G. F. Bruckmann, Munich.—Photograph.
R. Gebrüder Alves, Berlin.—Gold furniture.
H. G. Thallmeier, Fr. H., Munich.—Porcelain.
H. G. Rudolf Barheine, Berlin.—Chimney pieces.
H. G. L. W. Grimm, Schwarzenbach, Bavaria.—Serpentine Stone.
H. G. Saxon Serpentine Stone, Zöblitz.—Serpentine Stone.
H. G. Ch. Seidel and Son, Dresden.—Majolica Stoves, Rococco style.
H. G. Silesian Looking Glass Company, Ober-Salsbrunn, near Waldenburg.—Large sheet of glass.
H. G. Silesian Earthenware Company, Tschauschwits, near Neisse.—Large stove.
H. G. Mannheim Glass Works, Ober-Salsbrunn, near Waldenburg.—Large glass.
R. Nephew of Franz Steigerwald, Munich.—Glass ware.
H. G. J. S. Schmidt, Weimar, Saxe-Weimar.—Stoves and terra-cotta.
H. G. Company of Looking Glass Manufacture and Chemical Works of Saint Gobain, Chauny and Cirey.—Stolberg, near Aix la Chapelle.—Chemical Trophy.
R. Villeroy and Boch, Mettlach.—Porcelain trophy.
H. G. Prussian Amber Company.—Display of Raw Amber from Company's quarries at Königsberg.

H. G. H. A. MEYER, HAMBURGH.—Large ivory trophy, raw and manufactured.
R. DANIEL ALTER, DANTZIG.—Amber.
R. J. C. FRANK, STOLP, POMERANIA.—Amber.
R. BERNHARD LIEDTKE, KÖNIGSBERG.—Amber.
R. JULIUS SCHLUNK, BERLIN.—Leather.
R. G. LÜTTRINGHAUS and Co., MÜTHEIM, near COLOGNE.—Galanterie ware.
R. JULIUS CARSSOW, MERSEBURG, PROVINCE OF SAXONY.—Galanterie.
H. G. H. STERN, OBERSTEIN, OLDENBURG.—Cameos, onyxes, and crystals.
H. G. E. GOTTLIEB, OBERSTEIN, OLDENBURG.—Cameos, onyxes, and crystals.
R. H. C. MEYER, junr., HAMBURG.—Fancy wares.
H. G. A. W. FABER, NÜRNBERG, BAVARIA.—Nephrite and Graphite trophy of pencils and ornaments.
R. SCHWANHAUSSER, NÜRNBERG.—Pencils.
H. G. JOSEPH ALBERT, MUNICH.—Portraits and enlargements.
H. G. AUG. COLAS-BAUDELAIRE, STRASBURG, ALSACE-LORRAINE.—Photographs.
H. G. AD. BRAUN, DORNACH, ALSACE-LORRAINE.—Photographs.
H. G. RÖMMLER and JONAS, DRESDEN.—Photographs.
H. G. LÖSCHER and PETSCH, BERLIN.—Photographs.
H. G. DUISBURGER MACHINE Co., RHINE PROVINCES.—Iron Machinery.
H. G. G. SEGBOLD, LANDAU, BAVARIA.—Clocks for railways.
H. G. W. BROCKING, HAMBURG.—Astronomical clocks.
H. G. MATHIAS PETERSEN, ALTONA.—Clocks and new system escapement.
R. J. MANNHARDT, MUNICH.—Large turret clock.
R. G. F. STEINMEYER and Co., OETTINGEN, BAVARIA.—Large organ.
R. HERRMANN GEISTER, BERLIN.—Tower pinnacle, lightning conductors and vanes.
H. G. J. STEINMETZ, MUNICH.—Saloon decoration.

THE AUSTRIAN EMPIRE.

R. WILHELM RITTER VON FRITSCH.—Model in relief.—Mining, quarry, and metallurgy.
H. G. HOFMANN, GRAZ, STYRIA.—Stearine candles, &c., trophy.
R. F. A. SARG and SON and Co., LIESING, near VIENNA.—Stearine candles, &c., trophy.
H. G. TREU, NUGLISH and Co., VIENNA.—Perfumery.
H. G. A. M. POLLAK, VIENNA.—Matches.
R. ANTON HIMMELBAUER and Co., STOCKERAU, near VIENNA.—Stearine trophy.
R. 1st AUSTRIAN SOAP WORKS, VIENNA.—Stearine trophy.
R. FÜRTH WOLF and Co., STRAKONITZ, BOHEMIA.—Turkey carpets.
R. HOLLESCHOWITZER COTTON MANUFACTORY Co., PRAGUE.—Cotton goods trophy.
R. GIUSEPPE BOSSI, UNTER ST. VEIT, near VIENNA.—Drugs.
R. LOWENFELD, UNTER ST. VEIT, near VIENNA.—Soft goods trophy.
H. G. FL. KLAUBERT and SON, ASCH, BOHEMIA.—Web goods.
H. G. ED. GEIPEL, ASCH, BOHEMIA.—Web goods.
H. G. C. F. HOFMANN, ASCH, BOHEMIA.—Cotton and Web goods.
H. G. GEBRÜDER ADLER, ASCH, BOHEMIA.—Web goods.
H. G. GEIPEL and JÄGER, ASCH, BOHEMIA.—Web goods.
H. G. 1st AUSTRIAN JUTE SPINNING Co. SIMMERING, near VIENNA.—Jute trophy.
H. G. G. A. BAREUTHER and A. THORN and Co., VIENNA.—Stuff trophy.
R. M. FABER and Co., LETTOWITZ, MORAVIA.—Woven goods.
R. LUDWIG DAMBÖCK and FABER, MORAVIA.—Woven goods.
H. G. S. JAEGERMAYER, VIENNA.—Calicoes and linens.
H. G. BREVILLIER and Co., VIENNA.—Calicoes and linens.
R. NEPHEW of FRANZ THILL, VIENNA.—Uniforms.

R. Albert Wolff, Vienna.—Furniture goods.
R. Julius Pfeifer, Rumburg, Bohemia.—Furniture goods, cosmanos and reps.
R. Franz Leitenberger, Grottau and Haindorf, Bohemia.—Furniture and damask trophy.
R. Countess Pauline Baudissin, Vienna.—Artificial flowers trophy.
R. Heinrich Müller, Vienna.—Saddlery.
R. J. N. Reithoffer, Vienna.—India-rubber goods.
H. G. C. Wikede and Son, Vienna.—Saddlery.
R. Gebrüder Brünner, Vienna.—Petroleum lamps.
R. Albert Samassa, Laibach.—Bronzes.
R. J. L. Hermann, Vienna.—Nickel (China silber).
R. Hermann Ratzerdorfer, Vienna.—Gold and silver ware.
H. G. H. A. Granichstaden, Vienna.—Jewellery and precious stones.
H. G. J. Klinkosch, Vienna.—Silver ware.
H. G. 1st Austrian Fire-proof Safe Co., Vienna.—Fire-proof safes.
H. G. Berndorfer Metal Factory, Berndorf.—Alpacca silver.
H. G. Emil Biedermann, Vienna.—Jewellery and precious stones.
H. G. Kobek and Aegidi, Vienna.—Jewellery and precious stones.
R. Conratz and Reuter, Vienna.—China silber.
R. Eduard Rudolf Lackner, Vienna.—China silber.
R. Gustav Simon. " "
H. G. Prince Salm, Blanksо, Moravia.—Trophy of iron work.
H. G. Franz Schönthaler, Vienna.—Furniture.
H. G. Konrad Bühlmayer, Vienna.—Furniture.
R. Fischer and Mieg, Pirkenhammer, near Carlsbad, Bohemia.—Porcelain.
H. G. and R. Josef de Cente, Vienna.—Terra-cotta.
H. G. Albin Denk's Widow, Vienna.—Porcelain ware.
H. G. Haas and Czizek, Porcelain Works, Schlaggenwald, Bohemia.
H. G. Count Franz Harrach, Neuwelt, Bohemia.—Bohemian glass.
H. G. Andrea Francini, Vienna.—Marble chimney piece and statuette.
R. Johann Rint and Son, Vienna.—Fancy goods.
R. Johann Etz, Vienna.—Leather galanterie.
H. G. J. Schütte, Vienna.—Wood fancy goods.
H. G. Ludwig Hartmann and Eidam, Vienna.—Meerschaum and amber pipes.
H. G. F. Rosenberg, Vienna.—Meerschaum and amber pipes.
R. KK. Company Paper Works, Schlogelmühle.—Monster roll of paper, nine and a half miles in length.
R. L. Hardtmuth and Co., Büdwas, Bohemia.—Drawing requisites.
H. G. H. Engel and Son, Vienna.—Lithography.
R. and H. G. Josef Löwy, Vienna.—Photographs.
R. A Collective Trophy of Viennese Photographers.—A. Angerer, L. Angerer, V. Angerer, F. Antoine, M. Auerbach, Baldi and Würthle, Louis Bauer, Beer and Mayer, W. Burger, Carpentier and Eberling, A. F. Czihak, Eder and Nowicki, J. B. Feilner, Berthold Fiby, Vienna Photograph Association, M. Frankenstein and Co., J. Gertinger, A. Goldmann, K. Haak, C. F. Haufler, Heid. Henner, Hoffmann, Hornig, Jaffe, Jantsch, Klöcs, Knebel, Koller, Kozies, Kramer, Kroh. Krziwanek, Leth, Lobenwein, Lorenz, Löwy, Luckhardt, Manteufel, Martini, Matznler, Mioni, Pokorni and Reuter, Wendling, and others, 91 in all.
H. G. L. C. Zamarski, Vienna.—Lithos.
H. G. Julius Gertinger, Vienna.—Photos.
H. G. Adele Perlmulter, Vienna.—Photos.
R. L. Plössel and Co., Vienna.—Optical instruments.
H. G. J. B. Streicher and Son, Vienna.—Piano.
R. Rieger and Son, Jägerndorf, Silesia.—Church organ.
R. V. F. Czerweny, Königgratz, Bohemia.—Brass instruments.

H. G. Ehrbar and Bösendorfer, Vienna.—Piano.
R. Karl Hesse, Vienna.—Large church organ with 92 Repeaters.
H. G. Grego Zawadil, Znaim, Moravia.—High altar, gilt and painted.
H. G. Augemeine Deposit Bank.—Statistical tables.

HUNGARY.

H. G. Karl Ildenyi.—Inlaid wood and carvings.
H. G. Josef Engel.—Sculpture.

RUSSIA.

H. G. Alibert, J. P., Irkutsk, East Siberia, the discoverer of the mines.—Raw material of Graphite and Nephrite used by Faber of Nürnberg.—Trophy also shown by him at London, in 1862.
R. Russian-American India-rubber Co., St. Petersburg.—Exhibits in India-rubber and gutta-percha. Under Group 14, surgical bandages.
H. G. Adolf Morand, St. Petersburg.—Bronze and malachite.
H. G. Sergius Sasikoff, St. Petersburg.—Gold and silver ware.
H. G. Joh. Th. Spörhase, St. Petersburg.—Malachite and Lapis Lazuli articles.
H. G. Imperial Stone Works, Peterhof.—Malachite and Lapis Lazuli articles, and mosaics.
H. G. Imperial Glass Works, St. Petersburg.—Glasses and vases.
H. G. Imperial Porcelain Factory, St. Petersburg.—Porcelain.
H. G. Carl C. Köttger, St. Petersburg.—Photographs principally of antiquities, in Kertsch Museum.

To Sum up.

Beneath the Rotunda Roof, including the Half Gallery, there were 243 exhibits specified in Groups, 4 not in Groups, and 8 Refreshment Buffets.

The Exhibits under countries being as follows :—

GREAT BRITAIN	20
FRANCE.—This, though numerically small, really occupied at least her modicum of space, including as it did the great fountain and an enormous "Castle of Brass"	5
BELGIUM	7
SWEDEN AND NORWAY	7
DENMARK	11
SWITZERLAND	3
ITALY	14
GERMAN EMPIRE	92
AUSTRIAN EMPIRE	71
HUNGARY	2
RUSSIA	11
In all	243 exhibits.

Hugh Willoughby Sweny.

Vienna, December 1873.

MR. W. H. MAW *and* MR. JAMES DREDGE.

TECHNICAL PAPERS ON SPECIAL SUBJECTS OF THE EXHIBITION.

The Atlas of Plates referred to in the following Technical papers, and also in those printed in Volume II., is published by Mr. Charles Gilbert, 37, Bedford Street, Strand. The various Papers are referred to in the Atlas under the following heads :—

Section.	
I.	Exhibition Buildings.
II.	Mineral Fuel.
III.	Metals.
IV.	Iron and Steel.
V.	Boilers.
VI.	Stationary Engines.
VII.	Locomotives.
VIII.	Rolling Stock.
IX.	Marine Engines.
X.	Cranes.
XI.	Hydraulic Machinery.
XII.	Printing Machinery.

Section.	
XIII.	Sugar Making Machinery.
XIV.	Machine Tools.
XV.	Woodworking Machinery.
XVI.	Brickmaking.
XVII.	Ordnance.
XVIII.	Agricultural Machinery.
XIX.	Science Exhibits.
XX.	Building Materials.
XXI.	Civil Engineering.
XXII.	Educational.
XXIII.	Miscellaneous.

TECHNICAL PAPERS ON SPECIAL SUBJECTS OF THE EXHIBITION.

Contributed by W. H. Maw and James Dredge.

THE EXHIBITION BUILDINGS.

The Vienna Universal Exhibition of 1873 differed from all its predecessors in many important respects. It was determined before laying out the general design to avoid if possible all the errors and inconveniences which made themselves felt on previous occasions in London and Paris. As the intended correction of these errors was the basis of the design of the Exhibition, it will be well to detail them at once, in order that the *raison d'être* of the arrangements to be described hereafter, may be understood at a glance. It was considered that the principal of these defects were :—

1. The want of adequate direct railway communication to the very doors of the Exhibition.

2. The fact that the machinery department was always included in the same building as the general objects of exhibition, an arrangement which, from the noise and the smell of hot oil, was unpleasant to the general mass of visitors, who had to pass through the machinery rooms in order to get from one part to another of the general exhibition.

3. That the fine art department was always associated with, and sometimes even mixed up with, the general exhibition. This system exposed priceless objects of fine art to great risks from fire and other causes, and rendered artists and collectors extremely unwilling to exhibit their works and possessions.

4. The arrangement of the ground plan, which hitherto has been such that visitors have found it extremely difficult either to know where they were, or to find their way from the space belonging to one country or class of objects to that belonging to any other.

5. The system of lighting from the roof, the arrangements for which it is difficult, if not impossible, to render water-tight in temporary buildings—a fact which exhibitors in Paris in 1867 know to their cost. Moreover, in the scorching summers of Central Europe, it would have been intolerable to admit the sunlight directly through a glass roof.

Special efforts were made to correct these defects in the buildings for the Vienna Exhibition.

In the first place it was necessary to procure a site which could be put in direct communication by rail with all the railroads entering the metropolis. This was found in the Prater, the great public park of Vienna, a Hyde Park and Champs Elysées both in one, which is situated just outside the Leopoldstadt suburb, within a walk of 20 minutes from the centre of the city, and which is bounded on all sides by branches of the River Danube. It would have been impossible to obtain a situation better suited to all the requirements of an Exhibition. The Prater lies close to the town, and yet outside it. It is practically boundless in extent. The scenery in it is beautiful; and, moreover, it is the favourite resort of all classes of the inhabitants; the levels are such that it was found perfectly easy to run a railway through it which should connect together the Staatsbahn and Nordbahn, and by means of these two latter be put in direct communication with all the other railroads of the empire. This railway was accordingly made early in the spring of 1872. Where it entered the Exhibition grounds it was spread out into 11 branches or sidings, one or more running past the outside of each of the main buildings. By means of these sidings trucks containing building materials or objects of exhibition were conveyed direct to the very spot where they were wanted. The position of the station for passengers will be seen on the plan close behind the Machinery Hall (Plate I.). The first named inconvenience of past Exhibitions was thus overcome, and it was next determined that the buildings should consist of three main groups. One of these was reserved for general objects of exhibition, and is the building whose ground plan, as will be noticed, somewhat resembles a gridiron. Another was appropriated to

machinery of all kinds; it is seen on the plan parallel to the length of the Industry Palace, and is separated from the latter by a broad strip of park. The third is the Exhibition of Fine Arts; this is parallel to the eastern end of the Industry Palace, and is quite detached both from it and the Machinery Hall.

In this manner the defects enumerated under 2 and 3 were disposed of. The improved arrangement of the ground plan, and the new system of lighting, will be noticed in detail in describing the principal features of the individual buildings.

The first of these groups of buildings, the Industry Palace, consisted of a nave 900 metres (2,953 ft.) long by 25½ (83 ft. 8 in.) wide, and 22½ (73 ft. 10 in.) high. This nave was intersected by 16 transepts, each about 174·5 metres (572 ft. 6 in.) long, 15·579 (51 ft. 1 in.) wide, and 12·5 (41 ft.) high. The two transepts at each end were bound together by a short building parallel to the nave, thus forming four enclosed garden courts, while between the others the courts were open on one side. In the middle of the nave was situated the great Rotunda, the dome of which, about 106 metres, or 348 ft. in span, is the largest in the world, being fully one-third wider than the roof of the St. Pancras railway station. The nave, where it met the Rotunda, split in two, encircling the latter as a kind of ring or aisle. Intersecting the middle of this aisle was the great central transept, of the same height and breadth as the nave, which terminated at both ends in colossal triumphal arches, or entrances; while right and left, as far as the nearest of the small transepts, stretched handsome colonnades, forming a very fine façade to the central portion of the Industry Palace. Thus the Rotunda was enclosed in a quadrangle 206 metres (675 ft. 10 in.) square, which, together with the cruciform portion of the nave and great transept, is destined to form a permanent group of buildings, which will remain as a monument of the Exhibition long after the surrounding edifices have been removed.

The second great block of buildings, reserved for machinery, was, without doubt, one of the most interesting features of this Exhibition. It consisted of one continuous edifice, 800 metres (2,625 ft.) long, by 50 (164 ft.) broad. There were two central lines of shafting, and two lines of rails traversing it from end to end. These rails joined the branch line running through the Prater, and by means of them it was possible to unload each machine within a few feet of the spot destined for its erection. The building was divided into a nave and two side aisles. Structurally the nave consists of a series of massive brick piers, on the tops of which rest the iron trusses of the roof. The piers are all connected together by flat arches springing from the middle of their height; the spaces above the arches are filled with windows, while the part below is left open as a free passage from the aisle to the nave. The aisles also consist of similar smaller piers, the panels between being taken up entirely by the windows. The roof of the nave is formed of iron trusses 29·5 metres (96 ft. 9 in.) in span, connected together by wooden purlins, and covered by planking laid diagonally, the whole being rendered watertight by zinc plating, a material very much used in Austria instead of lead or slates. The aisles are roofed in by a simple lean-to, supported by iron girders, and covered by planking and zinc. The boilers, which were contained in separate sheds at the back of the main building, were all objects of exhibition; there were five of these sheds, and consequently as many different sets of boilers, all employed for the working of the main shafting. It was intended to test their different qualities, such as steam-producing power, economy of fuel, freedom from priming, &c., and finally to award a prize medal to the system which gave the best results. Architecturally speaking, this hall is anything but handsome from the exterior, though from the inside the immense vista of piers and trusses has an astonishing effect. The outside is one long monotonous row of windows set in cold, grey plaster, and surmounted by a still colder-looking roof with no architectural embellishments or prominent projections to relieve the eye; fortunately, however, it was not felt as an eyesore, for the numerous pavilions and trees which occupy the broad strip of ground lying between it and the Industry Palace hid it from view, so that it was never seen as a whole.

The last of these three groups of buildings was the picture gallery; it was a handsome structure of brick cased with cement, and richly adorned. It

was, however, a building in which the engineer played no part, and need not therefore be further described here.

When the applications for space came to be considered by the Imperial Commission in the summer of 1872, it was found that both the Industry Palace and the Machinery Hall, large as they were, could not contain all the objects announced for exhibition. Hence it was necessary to make some further arrangements in order to meet this new demand. It was determined that no agricultural engines or implements should be admitted into the Machinery Hall, but that instead, two separate annexes should be erected, the one at the extreme south-east, and the other at the south-west end of the main building, the former to contain the agricultural tools and products of Germany, Austria, and Russia, while the latter was to be reserved for England, France, Italy, and America. These two buildings will be seen on the plan, the one beyond the south-eastern ends of the Industry Palace and Machinery Hall, the other lying between the western ends of the first named buildings, and immediately to the right of the English Commission House and the waterworks tower. By means of these supplementary buildings the Machinery Hall was enabled to meet all requirements. The lack of space in the Industry Palace was provided for, first, by banishing the restaurants out of the main building into separate detached houses, which are to be seen scattered about the park in every direction; second, by allowing the countries which had possession of the transepts, to occupy also the garden courts between these transepts, and, if necessary, to roof them over; and, third, by permitting those countries which had very large exhibitions, to erect separate buildings in the park for their own use, and at their own expense, a privilege of which Germany has largely availed herself.

It was also found that the Fine Art Department would be fully taken up by the modern pictures announced for exhibition; hence it was necessary to erect two annexes to the great picture gallery which should serve as exhibition rooms for the large loan collections promised. They will be seen on the plan to the right of the picture gallery; one of them was given up to the collections of amateurs, while the other was appropriated to selections from the various national museums and galleries of Europe.

When there was such an urgent demand for space it was manifestly impossible to provide offices for the general direction, the custom house, the jury, &c., in the main building. In consequence, separate houses were erected for each of these purposes. On the right of the great avenue leading up to the grand entrance of the Rotunda will be seen the post and telegraph offices and custom house, all in one block, while opposite to it on the left was situated the Austrian Commission House, containing the offices of the chief manager; further up the avenue we pass the Imperial Pavilion on the right, and the Jury House on the left hand side—these two latter very handsome buildings, The emperor's pavilion in particular was one of the great sights in the grounds, for all the principal decorators and upholsterers of Vienna fitted it up at their own expense in the most costly and elaborate style, as an exhibition of their respective trades. The Commission and Custom houses were excessively picturesque and convenient, and were, moreover, quite novel in style and design. They each consisted of a one-storied-range of buildings surrounding two small garden courts, the plan of the whole being an oblong. They were made of wooden frames, filled in with brick in the Swiss châlet style, and plastered over for protection against the weather. Along the outside stretched a broad verandah of the same height as the building itself. This verandah was supported by handsome carved wooden pillars, covered by a trussed V-shaped roof, and was paved with asphalte; similar, but narrower, verandahs surrounded the garden courts, and served as passages of communication: thus the whole of the house itself was filled by the rooms without any loss of space. The offices were all *en suite*, and had each a door giving on the court. It would be difficult to imagine any style of temporary building cheaper or better suited to its purpose.

One peculiarity of this Exhibition should not escape notice; all the entrances to the park, whether by road or rail, being at some little distance from the Exhibition itself, it was thought advisable to connect these entrances with the buildings, and the buildings with one another, by covered ways, which could be used equally as a shelter against sun and rain (see Plate II., Figs. 1,

2, 3, 4). Accordingly, broad roofed passages, with tiled or asphalte floors and open sides, were erected, connecting the grand entrance to the park with the Commission and Custom Houses, the Industry Palace, the Machinery Hall, and the Railway Station. The tiles and asphalte employed in the pavement were objects of exhibition, and prize medals were awarded to the best specimens. The roofing was supported by carved wooden pillars, in the same style as those of the verandah of the Commission House. These passages, besides being found very convenient, added greatly to the appearance of the grounds.

Precautions against fire received more attention in this Exhibition than on any previous occasion. Large waterworks were erected, which gave an unlimited supply of water at a pressure of 22 lb. per square inch to the numerous hydrants on the outside, and in the interior of every building; moreover, watch houses, each containing a fire engine complete, with the necessary contingent of men, were erected in a number of places; these engines could draw their supply either from the water service or from tanks which were specially erected for their use in every convenient position. In addition to this the principal buildings were so constructed that they could be easily cut in two, and thus if a dangerous fire arose it could be isolated, and confined to that portion of the building in which it originated.

It was considered when designing the Vienna Exhibition, that no one system could combine in itself all possible advantages, and consequently it was determined to sacrifice that particular feature which, however, contributed largely to the general organization of the whole. It was seen at once that if the juxtaposition of all objects of the same class was abandoned, then all the faults of the Paris exhibition could be corrected. The gridiron plan was the special arrangement chosen to meet all these difficulties. It was originally the idea of the two Viennese architects, Sicardsbourg and Van der Null, the builders of the famous Opera House of Vienna, both of whom are now deceased. They left behind them nothing but a crude sketch of a ground plan which as they designed it, was utterly impracticable. The idea was, however, retained and rendered feasible by Mr. Charles Hasenauer, who was the chief architect of the entire Exhibition. The rationale of the system is as follows:

The nave or great axis of the building was made to run as nearly as possible east and west. The transepts consequently pointed north and south. The countries were then arranged according to their geographical position on the surface of the earth. North and South America occupied the extreme western end of the building; England and the countries of Western Europe came next, and so on till we get to the far eastern transepts, which were appropriated to China and Japan. In the case of two countries being the same distance east or west of a given meridian, the one which lies most to the north on the face of the globe occupied the transept and part of the nave on the northern side of the axis, and *vice versâ*; this latter rule was sometimes disregarded, as it did not destroy the working of the system.

By means of this arrangement, the visitor could find his way about with perfect ease. To give an example: if a visitor found himself in one of the transepts belonging to France, and wanted to go to the Chinese portion of the building, knowing as he does that China lies to the east of France on the surface of the globe, he had only to go into the nave, turn towards the eastern end of the long axis, and walk till he saw the name CHINA hung up from the roof in large letters. If, on the other hand, he wanted to visit the American department, he would have performed precisely the same operation, turning, however, towards the west instead of to the east. It was equally easy for visitors who were in the park to find their way from the outside to any particular part of the Industry Palace, for each transept was furnished with a portal at its end, over which was marked the name of the country occupying it.

It may be remarked with perfect truth that an equally simple arrangement could have been obtained without the gridiron plan, by the use of one plane oblong building also running from east to west, the countries being arranged precisely as above. Such a construction would, however, have several grave defects. The façade of a building half-a-mile long, unrelieved by transepts or other prominent projections, would have been, architecturally, intolerable.

In order to obtain an equal area of ground plan with the same length, the width of the building, and consequently the span of the roof girders, must have been increased fourfold. In order to light such a wide building effectively, it would have been again necessary to have employed a glass roof. The area of wall available for hanging purposes and for side windows would have been diminished fourfold; and lastly the garden courts, a pleasant and useful feature of the system adopted, would not have existed.

From the above it will be seen how far the gridiron plan met all the requirements of an exhibition. The great nave presented a splendid coup d'œil. The difficulty of finding one's way about scarcely existed. Thanks to the great extent of wall surface and the comparative narrowness of the nave and transepts, it was possible to light the whole building by side windows. The roof girders being of small span were very light, and the garden courts supplied the amount of wall space which each country required in the immediate neighbourhood of its own section of the Industry Palace.

On the other hand the system adopted involved a vast amount of walking, and a corresponding loss of time, while a more serious defect arose from the impossibility of actual comparison between the exhibits of different countries far removed from each other by reason of their geographical arrangement.

The general aspect from the outside was that of a long low line of grey buildings surmounted by an arched zinc roof; the long line being broken frequently by the numerous transepts, the end of each of which was a portico of considerable architectural beauty (see Plate XIV., Fig. 3, and Plate XVII.), the doorway in every case being surmounted by the name and arms of the country to which the transept belonged. Immediately under the cornice of the roof were the windows, oblong in shape, which ran right round the entier nave and transepts in one continuous line, broken only by the porticos mentioned above; the windows were separated from each other by piers of brickwork, containing lattice iron columns supporting the roof and its cornice; both piers and cornice were adorned by appropriate ornaments in dark brown on a grey plaster ground, in the cinque cento style. Beneath the windows were the side walls of the building, which were also of brick covered with plaster, so moulded as to resemble blocks of stone. The transepts were of considerably smaller dimensions than the nave; in fact, the crowns of the roofs of the former did not quite reach up to the tops of the windows of the latter, consequently the windows of the transepts were formed quite below the bottom line of those of the nave. This arrangement was adopted for two reasons; firstly, because the intersection of two arched roofs—always a complicated structure—would thus be avoided; and, secondly, because at every crossing of the nave with the transepts the nave would be lighted up not only from its own lofty windows, but also by the diagonal rays coming through low windows of the transepts. The proportions of height of walls and windows in the nave and transepts were so arranged that the cornice or stringer at the top of the blank wall of the nave, below its windows, on being continued round the transepts formed the cornice of its roof, and also the springing for the great arch of its portico, and thus ran round the entire building from end to end; while the corresponding stringers in the transepts formed the springing for the arches over the doorways, and were also continued on to the blank walls of the nave, where, together with the first-named cornice, it enclosed a large space on which were moulded ornamental tablets, inscribed with the names of the famous men of each country taking part in the Exhibition. This arrangement of the cornices on the two constituent parts of the building had the effect of bringing them into perfect relationship with each other, for thus each characteristic feature of the one was also a characteristic but different feature of the other.

A building such as has just been described would, however, have failed in two or three respects; it would have lacked a grand hall for great ceremonies and festivities; the long low line of buildings would have had no striking architectural effect, and the perpetual breaks caused by the ever-recurring transepts would have given the building too much of a straggling appearance. In consequence of all this it was determined to build a grand central hall surmounted by a dome of colossal proportions, which should at one and the

same time serve as a great arena for festivals and ceremonies, and should also be of architectural use in saving the whole building from commonplaceness.

Mr. Scott Russell was applied to by the Imperial Commission to assist in carrying out this great idea, and at once undertook the design of the Rotunda, in the middle of the Industry Palace. This building is entirely novel, both in its architectural and mechanical features; but as it will be described hereafter, it is not at present necessary to enter into its details. It was so designed that it would not crush the other buildings into insignificance, but form rather, their natural culmination and development. It was planted right in the middle of the axis of the nave, and in order to unify it with the remainder of the palace, the nave, where it met it, was made to split in two, and encircle it; the semi-arch of the roof of the nave thus split resting against the walls of the Rotunda. The straggling appearance of the buildings was now the only remaining fault; this was corrected by uniting the transepts which flank the Rotunda on either side by a transverse building parallel to the nave (see Plate II., Fig. 6). This building forms a handsome façade for the centre of the palace, and makes up together with the Rotunda a grand central block of buildings, from which on either side stretched the nave with its numerous transepts. The four corners of this central group are, for the sake of further emphasis, formed of pavilions surmounted by domes (see Plate III., Fig. 1), while in the middle of the front façade is a colossal triumphal arch, richly adorned with statuary and bas-reliefs, which forms the chief entrance into the Rotunda (see Plate VI., Fig. 2). Similar, but shorter façades flanked the Industry Palace at the two ends (see Plate III., Fig. 2, and Fig. 2, Plate XIII.); they were also provided with corner pavilions and domes. The six transversal buildings thus obtained were made use of for exhibitors, and lost property offices, waiting-rooms, &c. The *raison d'être* of each feature of the Industry Palace having now been described, we may proceed with the consideration of its technical details.

The Prater, or park on which the Vienna Exhibition was built, lies close to the river Danube; its soil is indeed a deposit of that stream, and consists, for the most part, of alternate layers of loose sand and gravel. Water is reached by penetrating, on an average, 10 ft. below the level of the ground. The surface of the park is very uneven, being intersected in every direction by deep chines or ditches, which were evidently once watercourses. These were the circumstances which determined the nature of the foundations. In a country where bricks are exorbitantly dear and bad, where wood is very cheap, where the nature of the soil renders shallow brickwork footings insecure, and where water is very soon reached, it is evident that piles were the proper system of foundations, and accordingly it was determined that wherever possible the Industry Palace should be built on piles. It was, however, considered expedient that the heavy walls of the nave, and the buildings which were destined to be permanent, such as the grand entrances and the ring aisle surrounding the Rotunda, should not be built on piles, but on solid concrete footings. Accordingly the nave, which was only a temporary building, was founded on a footing of rough concrete made of broken bricks, one metre thick at the base, while the heavy permanent buildings were provided with the best concrete footings made with pebbles from the river banks, on the top of which were raised the foundation walls of the best brickwork carefully grouted. All the small transepts, together with the buildings which formed the central and flanking façades, and also the flooring of the entire palace were founded on piles.

It was determined, in order to give importance to the Industry Palace, that it should stand on a terrace elevated about 2 ft. above the general level of the park. This end was secured by driving the piles till their heads stood at the required level above the ground, and then the terrace was formed artificially all round the building—but not between the piles—of gravel brought from the bed of the Danube along the railroads laid down for this and similar purposes.

The piles which formed the foundations of the buildings constituting the façades were an exception to the above rule, which regulated the general level. In this case the piles were driven in trenches about 2 ft. deep, the footing

being formed of strong beams connecting their heads; the top surface of the beam was in every case level with the bottom of the trench, and thus the footing was supported not only by the piles but also by the ground itself; this plan was adopted for these latter buildings because the whole weight of the roof had to be carried directly by the walls and not by iron columns, as was the case in the nave and transepts.

The piles which were used were on an average about 10 in. in diameter across the head. When used for wall foundations they were driven from 5 ft. to 6 ft. apart. and 10 ft. to 14 ft. deep. The heads of the piles were bridged over by beams 10 in. by 8½ in., and on these were built the side walls of the Palace (see Plate XVI). The foundations for each of the iron columns which supported the roofing consisted, in the case of the nave, of six piles, and in the case of transepts of four piles driven close together, their heads being connected by beams similar to those mentioned above. The piles which supported the flooring were driven at distances of 8 ft. 4 in. apart in the direction of the axis of the nave, and of 9 ft. 6 in. across it. The 9 ft. 6 in. distance was bridged over by beams 6 in. by 8 in., and across these beams were laid the flooring joists 3⅜ in. by 6¼ in., while lastly the flooring itself consisted of boards 6 in. by 1⅛ in. laid transversely to the length of the nave and transepts, considerable interstices being left between these boards, so that the dust might be swept through. It must be understood that there was no kind of cellaring or any subterranean structure beneath the floor; there was nothing in fact but the empty space between the natural surface of the ground and the tops of the piles, the sides being closed by the walls of the building.

The system of pile-driving by steam so much practised in England seems almost unknown in Austria. Every one of the thousands of piles employed in the Vienna Exhibition was driven by manual labour. The plan is as follows: A tripod is formed of poles, from the apex of which a pulley is suspended; over this latter is passed a strong rope, to one end of which is fastened the ram, weighing about 600 lb., while to the other end are fastened from 15 to 20 smaller ropes, each provided with a handle which is grasped by a labourer. The head of the gang stands on a ladder resting against the tripod, and guides the ram by means of an iron rod which passes through it, and rests in a socket in the head of the pile. The labourers lift the ram by pulling the handles of the ropes down to their feet, and let it fall by swinging their arms suddenly above their heads, a fall of about 7ft. being thus obtained.

It was originally intended that the superstructure of the Industry Palace should consist of wooden columns, supporting arched roof principals, which were also to have been made of wood. The columns were to have been connected together by timber frames, in order to give them lateral stability, while the walls were intended to have been formed by filling in the panels of this framework with bricks in the Swiss cottage style.

When this became known amongst the Austrian contractors, the prices of wood rose enormously, and the prices contained in the tenders were so exorbitant that the technical committee at once resolved to abandon the construction in wood for the nave and transepts, and resort to a somewhat similar one in light wrought-iron work, the contract for making which was awarded, after an international competition, to the firm of Harkort, of Duisburg, on the Rhine, in Westphalia.

The superstructure, as erected, consisted of wrought-iron lattice columns of the lightest possible construction, standing on cast-iron foundation plates, which were borne on piles. These columns supported the roof principals, which were parabolic arches, also formed of lattice work, and were connected one to another by wooden purlins, which rested in angle-iron sockets rivetted to the top flange of the arch. Over the purlins was nailed down a light wooden boarding, the whole being covered in and rendered water-tight by a plating of zinc. It will thus be seen that the entire weight of the roof was carried by the columns, the walls having nothing to do but to serve as a panelling. The columns were merely lattice-work girders, whose stiffness was altogether confined to the direction of their depth; the flanges were each formed of two 3½ in. angle irons rivetted together, while the web was formed

of diagonal strips and horizontal angle irons. The columns were so planted that the direction of their depth was at right angles to the walls, and thus it will be seen that they had of themselves no strength to resist buckling sideways. This want of lateral stiffness was made good by connecting all the columns together by strong timber frames, as shown in the engraving (see Plate IV.). The framework was, as has been before described, filled in with bricks, and plastered over both within and without. The walls thus formed were, in the case of the nave, one and a half, and in the transepts merely one brick thick. Lest this statement should give an erroneous idea of the strength of the walls, it should be mentioned that in Austria the bricks are considerably larger than in England, being $11\frac{1}{2}$ in. × $5\frac{3}{4}$ in. × $2\frac{7}{8}$ in. in dimensions. The outer flange of the columns was encastré in this brickwork, a fact which should be remembered, as it will be shown hereafter to have been followed by most serious consequences. There were three kinds of columns used in the construction of this building, viz.:—

1. The tall ones of the nave which were 17·4 metres (=57 ft. 1 in.) in length, by 1·4 metres (=4 ft. $7\frac{3}{16}$ in.) in depth.
2. The short ones of the transepts which were 10·75 metres (=35 ft. 3 in.) long, by 1·0 metres (3 ft. $3\frac{3}{8}$ in.) broad.
3. The composite columns which occurred at the junction of every transept with the nave; these latter consisted merely of the other two rivetted together so as to have an L-shaped plan.

The columns of the nave and transepts differed only in dimensions, the arrangement of their parts being exactly the same. The girders which carried the roof were simply lattice-work arches; the top and bottom flanges consisting of the same sized angle irons as those employed in the columns, namely, $3\frac{1}{8}$ in. The flanges of the arches were, however, stronger than those of the columns, being reinforced by the addition of a strip of plate iron 180 millimetres (=$7\frac{1}{16}$ in.) wide, by 10 millimetres (=0·4 in.) in thickness. The lattice work consisted of radial pieces of doubled angle iron, and diagonals of single strips; the three panels at the crown of the arch had crossed diagonals, while the two at the springings were formed of solid plate. At each intersection of the transepts with the nave, one truss of the roof occurred which had no columns to support it, and in consequence a supplementary iron structure had to be erected here, which consisted of a simple lattice girder resting on the two adjacent composite columns. The arch of the nave in question was made to bear both on this girder, and also on the transept arch immediately beneath it, the whole being stiffened by stout timber frames as shown in the engraving.

The manner of erecting the ironwork was at once simple and expeditious. In the case of the naves, after all the piles had been driven, four large travelling scaffolds were erected, which were moved on rails laid along the beams connecting the heads of the piles; each of them did one-fourth of the entire work. There were three windlasses erected on the top of each of these stages, viz., one in the middle for lifting the roof principals, and one at each side for erecting the columns. These latter arrived ready made in one piece, while the arches, for convenience of transport, were sent in two segments, which were rivetted together on the ground. Two opposite columns were first erected in their proper positions by means of the windlasses, and after they had been secured in position, the arch was lifted in one piece and deposited on and rivetted to their heads. The whole frame thus erected was next secured and prevented from falling by means of stay-ropes. The stage was then moved on to the position necessary in order to erect the next frame, and so on till the end. As soon as two or three sets of columns and arches had been erected, the carpenters were set to connect them by the permanent framework, and following immediately upon these latter were the bricklayers, plasterers, and zinc workers, who filled in the panels of the woodwork, covered the walls both within and without with plaster, and finished the roofing. Lastly came the glaziers and decorators, who put in the windows, finished the cornices and all the external decoration both in relief and in colour, and in fact completed the outside of the building.

The system of erection in the transepts was somewhat more simple. Thanks

to the exceeding lightness of the ironwork the travelling stages were dispensed with, and three cranes, each consisting of a simple pole with a pulley at the top, and a windlass at the bottom, were employed instead. The two columns and their connecting arch were then fastened together on the ground and lifted by means of the cranes into their proper position in one piece. The poles were then shifted, and so on as before, the carpenters, bricklayers, &c., following each other in quick succession, just as they did in the nave.

Between each pair of columns was situated one of the windows which served to light the building. The windows were so contrived that their frames formed part of the woodwork between the columns. There were twenty-six of them in every transept, each being 3·3 metres (=10 ft. 10 in.) long by 4·2 metres (=13 ft. 9½ in.) wide, while each segment of the nave contained ten, the dimensions of which were 4·6 metres by 4·9 metres (=15 ft. 1 in. by 16 ft. 1 in.) The windows in the so-called blind arcades, right and left of the great doorways at the two ends of the nave, were somewhat different from the above, being semicircular in shape, so as to form a continuation of the real arcades which form the flanking façades of the palace (see Plate V., Fig. 2).

This completes the description of the superstructure of the nave and transepts; the ring aisle surrounding the Rotunda, and also the transverse buildings which form the façades, were formed in quite a different manner.

The ring aisle being intended for a permanent building was constructed of solid brick piers connected together by arches, the whole being arranged in the Roman Renaissance style of architecture. The spaces between the piers are occupied by colossal windows, which serve to illuminate, not only the aisle, but also aid in lighting the Rotunda itself. The roof principals are formed of semi-arched girders, which are like those of the nave cut in two, with this difference, however, that whereas the nave arches are of lattice-work, those of the ring aisle are formed of solid plate. One end of each of these semi-arches rests on the brickwork pier, while the other is fastened to the iron columns of the Rotunda. The junction with the piers is horizontal, and that with the columns is vertical; thus the entire thrust outwards is balanced by the stiffness of the columns, while the piers have only to support part of the weight of the roof acting vertically downwards. There are two of these semi-arches fastened to each of the columns of the Rotunda, and they are all connected together by purlins and covered by boarding and zinc in precisely the same manner as are the trusses of the nave and transepts.

The buildings which form the façades being destined for offices of all sorts, it was not necessary to construct them in the same manner as the rest of the Palace. The following was the plan adopted: Instead of the iron columns and arches used in the transepts, a system of stout timber frames was employed. These frames run transverse to the length of the building, and form not only the skeletons of the partition walls between each room, but also the roof principals and the pillars of the arcade all in one. The frames were put together on the ground and lifted into position in precisely the same manner as were the iron frames of the transepts. They were then connected together by longitudinal frames and brickwork in the manner previously described. Only the back portion of these buildings was used for offices. The front is an arcade covered in by a groined ceiling, supported on the outside by columns and arches. The ceiling is very light, being formed of wooden ribs and laths, which are plastered over, and handsomely decorated with emblematic ornaments painted in fresco. The central portion of each of the columns is the outermost squared timber of the framework just described. This interior bone is covered over by a light turned wooden column, which really does no work in supporting the superstructure, but which was furnished with mouldings and a capital, and was plastered over so as to resemble stone. The corner pavilions were formed in precisely the same manner of timber and brickwork, and their domes consisted of curved wooden ribs supported by rectangular timber frames, the whole being covered in as usual by boarding and zinc plating.

As has been already stated, the Industry Palace, large as it was, could not furnish nearly enough covered space to meet the demands which were put

upon it. It was accordingly determined to cover in as many of the garden courts as were necessary, in order to make up the space wanted, and most of the courts in the rear, and some of those in the front of the building were sacrificed. Of course this increase in space was gained at the expense of appearances, and to a certain extent they interfered with the lighting of the building. They were simple structures of brick and timber, the form of roof adopted being shown in Plate II., Fig. 5. The area enclosed was 112 ft. 8½ in. wide, and 230 ft. long, and this space was covered by a central arched roof, 59 ft. 1½ in. span, and a side lean-to roof, 26 ft. 9½ in. wide, which ran around the whole of the area, exeept in one or two cases where the garden court was not entirely covered. The clear height of the building in the centre was 38 ft. 6⅜ in., and as the roof was unobstructed, except by a light tie rod to each principal rafter, the effect was extremely good. The lighting was excellent, and although the top lights may be open perhaps to the objection of throwning in too great a glare, this was a defect easily remedied by light canvas screens, which were in fact added. The height to the springing of the lean-to roof was 15 ft. 6⅞ in., and at the junction with the main roof it was 22 ft. 1⅝ in. It will be seen from the section that besides the skylight in the main span, there were side windows above the top of the lean-to roof, and a part of the latter were also glazed.

One of the French garden courts was entirely covered in this way, another was half covered, and a third was more partially roofed in. One American court was also entirely roofed, and one-third the area of an English court; besides this, one of the detached American buildings was constructed on this system. Simple and cheap as the design is, it was undoubtedly one of the most successful, if not absolutely the best mode adopted of covering in the garden courts, and the work reflects great credit on the French contractor who undertook the work.

All the important structural details of the Industry Palace have now been described, but it remains still to give an account of the internal decorations. The decoration of the Vienna Exhibition was a problem of the greatest difficulty to all concerned in it. So accustomed are the Viennese to a gorgeous style of decoration in all their public buildings, from their palaces and museums down to the commonest cafés and bierhalle, that it was felt by the architects that a quite plain building, or one even so simply got up as the Crystal Palace at Sydenham, would not meet with popular approbation. On the other hand, to go in for the style of richly painted walls and ceilings, common enough in the town, would not only have cost an immense sum of money, but could also never have been finished in time. They were fortunately helped out of this dilemma by the timely invention of an Italian, M. Bossi, of Milan, who discovered how to print patterns on common canvas in such a manner that at a little distance the effect thus produced could not be distinguished from real painting. Herr von Gugitz, who was associated with Messrs. Hasenauer and Korompay, as one of the chief architects of the Exhibition, heard of this invention while staying at Milan, and at once conceived the idea of applying it to the decoration of the Industry Palace. For a year previous thousands of square yards of this material were being prepared at the establishment of M. Bossi, near Vienna, and were ready to be hung in their proper places as soon as the walls were ready to receive them. The material when finished costs from 7*d.* to 1*s.* per yard, according to the colour, and has this great advantage over paper hangings, that it has no tendency to bag when applied to damp walls, and consequently can be used as soon as the structure is finished, without waiting for it to dry. Thus the difficulty of time and money was overcome, and the best method of applying the new invention to the existing state of things was all that remained for consideration.

It was necessary to fix upon a style of decoration which should do away with the commonplace railway station appearance caused by the perpetually recurring lattice-work columns and arches. The original intention was to cloak the flanges of the iron standards which were not buried in the brickwork of the walls with ornamental columns of light woodwork, which should seem to support a cornice from which the arches of the roof would appear to spring, but an unforeseen accident occurred which rendered a slight but very expen-

sive modification of the above plan necessary. It will be remembered that the columns were all supported on piles, which were independent of those piles which form the foundations of the walls. One flange of the standards, however, was not independent of the walls, but was, on the contrary, bricked into it for the sake of obtaining that lateral stiffness in which it was itself deficient, and was consequently liable to be affected by any movement of the walls caused by a sinking of the foundations, a shrinking of the brickwork or otherwise. Some such movement is precisely what occurred. Probably the piles which supported the walls of the transepts sank under the weight of the brickwork, carrying with the latter the encastré flanges of the columns, while the free flanges, being carried by independent piles, were prevented from sinking equally with the other, and were in consequence bent into S curves, the bending taking place in a plane parallel to the wall. A great many instances of this occurred directly after the walls were built, and as it was thought quite likely that in process of time the whole of the walls might sink a little, it was deemed necessary to provide against such a contingency by so strengthening the free flange, that it would be enabled to resist any buckling strain to which it would be subjected. This end was accomplished by bolting large round timbers 12 in. and 13 in. in diameter to the outer sides of the flanges in question. The timber was first turned quite round to the required diameter so that it might be employed also as an ornamental column. Then a strip bounded by about one-quarter of the circumference was sawn off in order that the flat side thus obtained might butt directly against the flange. This strip was then sawn in two, and one-half laid in the corner of each of the angle irons which form the flange. The whole was lastly bound together by wrought-iron straps, and bolts passing through both timbers and angle irons. Thus it happens that the chief feature of the decoration of this building was not a mere encumbrance or make-believe, but was a real integral portion of the structure itself, and thus fulfilled the most essential requirement of the modern theory of ornament. The decorative character of the columns was completed by furnishing them with light wooden pedestals and mouldings and plaster-of-Paris capitals, all painted to resemble bronze, while the smooth portion of the timber was covered with tightly strained crimson canvas, adorned with spiral lines in gold. The columns carried a handsome cornice made of wood and painted of a creamy grey colour picked out with gold. From this cornice the roof girders seemed to spring. The latter were left perfectly plain and were painted olive green, the boarding of the roof behind them being whitewashed in order to obtain a light effect. Between the columns the walls were decorated in the following manner: The lower portion, as it was destined to be partially covered by the cases containing objects of exhibition, was simply painted in panels of a light neutral green, which harmonised remarkably well with the crimson of the columns; while above, the piers between, and the portions of the wall around the windows, were covered with canvas in its natural colour, but printed with arabesque patterns in dark blue and orange. It was utterly impossible for any spectator standing on the floor to distinguish this printed canvas from the most carefully executed painting. It will thus be seen that the decorations were confined to the walls of the building, the roof being left perfectly plain. The screens which separated the nave from the ring aisle, and also the several grand entrances and vestibules, were each the subject of very rich decorations in stucco, some of the details of which are shown in the illustrations.

There remains now nothing of interest to be described in connexion with the Industry Palace but the ventilation, which was, indeed, effected without any specially designed means. The Rotunda naturally acts like an enormous ventilating chimney; the sun acting on the vast surface of the roof heats the air underneath, which then immediately rises and escapes through the windows of the two lanterns, its place being supplied by more air gathered from the whole of the nave and the transepts; these latter in their turn obtain their fresh supply through the numerous open doors in every part of the building, while in addition special gratings for the purpose are fixed in the walls beneath the level of the flooring. It formed, in fact, a self-acting ventilating system, for the hotter the sun the greater was the action of the

roof of the Rotunda, and consequently the greater the rapidity of change in the buildings below. In addition to all this, every one of the windows in the entire Palace could be opened or shut at pleasure, and as they were situated so near the roof, each one of them could be used as an independent ventilator.

It has been already stated that the "gridiron" ground plan for the Industry Palace, convenient as it was in most ways, was wanting, nevertheless, in two important respects, viz., it presented architecturally a monotonous appearance from the outside, and it failed to provide a grand covered arena for state ceremonies. It was in order to make good these two defects that the erection of a great central building was determined upon. The idea first occurred to Baron Schwarz in the early part of the year 1871. He had at that time been already appointed to the post of General Director of the Exhibition, but was unfortunately shut up in Paris, which was then undergoing the German siege. After the capitulation, Baron Schwarz was still detained there by his duties as Consul General for Austria, and it was not till the end of May that he was enabled to proceed to London, in order to enter into negotiations with Mr. Scott Russell, whose ideas about domes he had first learned in the year 1851, when employed as Chief Commissioner for Austria to the London Exhibition of that year. Mr. Scott Russell's first idea was to construct a dome 800 ft. in diameter, but as it was impossible to find either room or money for so gigantic a structure, it was eventually arranged that he should prepare designs for a building which should not exceed the width of 400 ft., the settling of the exact dimensions being postponed till the architects had made their general plans and dispositions for the whole Exhibition. Time was, however, very pressing, for these general plans had to be submitted to the Imperial Commission at their first great sitting, held early in September 1871, and as Mr. Scott Russell's designs had first to be examined and accepted by the Technical Committee of the Commission, the drawings and estimates had to be prepared in a great hurry. With the hastily prepared designs Mr. Russell started for Vienna towards the beginning of August, and laid them before the members of the Technical Committee, by whom they were accepted, after a long and searching inquiry into the minutest detail, their final opinion being recorded "that Mr. Scott Russell's idea was ingenious, excessively simple, and, moreover, well suited to show how iron could be employed in a new and hitherto untried manner."

Mr. Russell then returned to England provided with all necessary information, and prepared a new set of drawings which differed from those first sent merely in the diameter of the dome, which was now limited to 354 ft. These designs were ready and lithographed by the second week of September 1871, when Mr. Scott Russell set out for Vienna, accompanied by Mr. Holmes, who was appointed to represent Mr. Russell, whose other duties both at home and abroad prevented him from giving his undivided attention to the Vienna Exhibition. In the meantime Mr. Hasenauer, the chief architect to the Commission, had prepared an architectural elevation of the building, photographs of which, together with the three outline drawings of the ironwork (see Plate VII., Figs. 2 to 10), mentioned above, and a short but clear specification, formed the sole materials from which the intending contractors had to form their estimates and send in their tenders. These data were forwarded to several of the best firms in Europe on the 21st of September, and on the 7th day of October all the tenders which had been sent in were opened, when it was found that Mr. John Caspar Harkort, of Duisbourg, in Westphalia, had made the most advantageous offer, which was accordingly accepted. We shall presently reproduce the original specifications and conditions of tender, together with a condensed account of the final terms of contract. In the meantime we may proceed to describe the building, and to give a general notice of the mechanical principles The elementary geometrical form of the building (see Plate VII. Fig. 1) is that of a cylinder 80 ft. in height and 354 ft. in diameter, surmounted by a conical roof inclined at an angle of 30° 45′. Where this cone narrows into 100 ft. diameter a great cylindrical lantern arises 30 ft. in height and necessarily also 100 ft. in width, this lantern being roofed over by a second cone inclined at the same angle as the first, which also terminates in a second lantern 30 ft. in diameter. This upper lantern is surmounted by a dome, on the summit of which

rests the Imperial Crown of Austria. The conical roof is formed of continuous iron plating, and hence admits no light whatever; it was for this, as well as for architectural reasons, that the lanterns were introduced, for in their sides are contained the windows which serve to illuminate the interior of the building. So much for the mere geometry; we come now to the mechanical features.

Beginning at the extreme bottom: it was originally intended that the lower cylindrical portion should be formed of a brick wall founded on a continuous ring of concrete. The piers of this wall, however, instead of being also of brick, were to have been wrought-iron columns of double T-shaped section (I), formed of plating the maximum thickness of which at any place was to have been ½-in., and of angle iron the dimensions of which were to have been 4 in. × 4 in. × ½ in. There were to have been 30 of these piers or columns placed at distances of 36 ft. apart from centre to centre, and their dimensions in plan were 10 ft. in the direction of the radius, and 4 ft. at right angles to it. The bottom of each column was to have been a foundation plate of wrought iron ½ in. thick, resting on timber balks placed on the concrete foundation, while the top was inclined at the same angle as the roof, to which indeed it was rivetted. The webs of the girders which formed the columns were to have been stiffened by wrought iron bulkheads placed at intervals, connecting the two flanges, and also by the brickwork of the walls, in which the whole column was to have been encastré, while the flanges would have been rendered rigid, not only by the two above-mentioned means, but also by angle irons at their edges, which would have run continuously from top to bottom of the columns. It is evident that these piers, looked upon as girders, possess no stiffness whatever except in the direction of the radius of the circle which forms the ground plan; and indeed it is only in this direction that any stiffness is required, for in the direction of the circumference the walls supply all the rigidity necessary, and moreover it is impossible that with a continuous concrete foundation ring, any transverse strain requiring lateral stiffness to resist it, should come upon the columns.

This arrangement of piers and walls was, however, dispensed with, for reasons of general convenience. It was determined to connect the Rotunda with the rest of the Industry Palace by opening the nave and great transept on either side directly into it, and by encircling it with a ring aisle which should consist simply of the nave split in two longitudinally. Now with 30 columns it is evident that one on either side would have been planted directly in the axis of the nave, thus obstructing the thoroughfare and the view, hence it became necessary to remove these two columns, and to substitute for each of them two others precisely similar, which should be placed one on either side of the longitudinal axis at a distance from it of 18 ft. Thus the total number of columns was increased to 32, and instead of their all being 36 ft. apart, there were four pairs of them which were at intervals of only 18 ft. (see Plate VI., Fig. 1). These 18 ft. spaces were used to accommodate the staircases and lifts by which access was to be gained to the galleries in the roof and lanterns.

As the Rotunda was now to be encircled with a ring aisle, it was no longer necessary to fill up the spaces between the piers with a heavy brick wall, whose only remaining function would have been to stiffen the columns. This latter object would have been amply attained as follows:—It was originally intended that the interior of the Rotunda should be a gigantic amphitheatre, the successive tiers of steps of which could have been used at one and the same time for exhibition galleries, and for the accommodation of thousands of sight-seers at any grand ceremony or festival. This amphitheatre was to have been made of wood, and the ponderous timber staging required to support it between the columns would have been more than sufficient to stiffen these latter for the lower 30 ft. of their length. The rigidity of the upper portions was to have been provided for by connecting the columns one to another by arches and timber framing, which, together with the continuous plating and the stiffening girders of the roof, would have been enough to prevent any lateral deflection whatsoever. It was on the supposition that these architectural arrangements would hold good, that the final drawings and specifications were issued to the tenderers; but at the last moment, after the tender of Harkort had been accepted, it was decided by the general management that the amphi-

theatre arrangement should be abandoned, and that the space between the columns should remain perfectly open in order to provide everywhere for free access between the Rotunda and the ring aisle. It had also been previously decided that, as the brick walls between the columns had been done away with, the continuous foundation ring was no longer necessary, and consequently each pier was made to stand on a separate concrete block of the shape of a truncated pyramid. These two changes at once altered the whole state of affairs. Not only was the chance of a transverse strain being brought to bear upon the columns greatly increased, for these detached foundations were much more likely to sink unequally among themselves than a continuous ring would have been, but also the power of the columns to resist these strains was altogether taken away by the removal of the timber staging. Hence it became necessary to design each pier so that it should be capable of resisting strains in every direction; and also the roof with its stiffening rings, had to be designed on the supposition that if any particular foundation sunk, the column standing on this foundation, instead of helping to support the roof, would be left hanging from the roof, and would have to be supported by it. These contingencies were provided against as follows:—The double T-shaped section of the columns was abandoned, and instead of it a box-shaped section was adopted. By this arrangement, when transverse strains in a radial direction were brought to bear, the two ends of the box would act as the top and bottom flanges of an ordinary girder, the sides, 10 ft. deep, performing the duty of a web, and *vice versâ*, under the action of transverse strains at right angles to the radius, the two sides would do duty as flanges, and the ends play the part of the web. The box was stiffened so as to prevent crumpling or spreading by numerous horizontal bulkheads of plate iron, the details of which, together with those of every other portion of the ironwork of the Rotunda, are clearly shown in the plate (see Plate VIII.).

Passing from the columns to the roof it will be seen at once that a cone of simple sheet iron whose maximum thickness at the bottom was $\frac{1}{8}$ in., amply strong though it would be to resist all the mere compressive and tensile forces to which it would be subjected when loaded symmetrically, would nevertheless not have been stiff enough of itself to keep its shape when acted upon by unsymmetrical loads, such as snow and wind on one side, and nothing but the inherent load of the roof itself on the other side. In order to provide against such contingencies, it was necessary to supplement the cone by a stiffening structure, whose function should be precisely that of the extra metal put into a strut over and above the theoretical amount required to resist the mere compressive strain. The stiffening construction in question consisted of a series of light radial and ring girders. The radial girders, 30 in number, stretch from the heads of the columns towards the imaginary apex of the cone. Two of these girders, however, namely, those which lie in the axis of the great nave, have no columns to rest on, and consequently lie simply on the roof. Over the centres of the columns they were each to have been 5 ft. in depth, and were to have been so tapered that they would, if prolonged, have ended in a point at the apex; they were to have consisted of a web of plate whose maximum thickness over the columns would have been $\frac{1}{2}$ in., and a light top flange of the same thickness, while the plating of the roof itself would have formed the bottom flange. The angle irons connecting the flange, web, and cone to one another would have been 4 in. × 4 in. × $\frac{1}{2}$ in., and would all have been single instead of double, as is usually the case; that is to say, instead of there being two angle irons, one on either side of the web, to connect it with either flange, there would have been one; a similar arrangement was adopted with perfect success in the construction of the Great Eastern steamship.

The concentric ring girders, 11 in number, were to have been formed in a precisely similar manner, the roof as before forming their bottom flanges. As the rings stood at right angles to the cone, they each formed a truncated cone pointing downwards. Each segment between the radial girders had its stiffening power over the roof increased by connecting it with the latter by means of three triangular brackets, one edge of the triangle being rivetted to the ring, and the other to the roof. The two lowermost of the ring girders were placed over the outside and inside edges of the columns; their functions are slightly different to those of the others, for when the ring-

supporting wall of the Rotunda was taken away these girders had not only to stiffen the cone, but also to support the weight of the roof between each column, which weight was originally to have been borne by the wall. Not only this; they were designed strong enough to bear the weight of every alternate column, in case the foundations of these latter should sink and leave them hanging in the air.

The cone itself was to have been formed of simple tapering plates whose maximum thickness over the columns was to have been $\frac{1}{2}$ in. diminishing to nothing at the apex. There were to have been 12 plates between each column, laid alternately top and bottom, so as to admit of being lap-rivetted at the sides, and so arranged as to break joint. The ring girders were only rivetted to the top plates, the spaces between the ring and the bottom plates being left vacant, so as to allow the rain to flow freely down. By this arrangement the cone could have been built up of concentric tiers of plates, there being two sets, each of 180 exactly similar plates in every tier at the bottom, and of course fewer at the top, an arrangement which would have introduced great simplicity and economy into the manufacture; for on account of the immense number of plates of the same size it would have been possible and convenient to have had each plate out to its required shape directly at the rolling mills, instead of having to be cut twice, first square at the mills, and then taper at the contractor's workshop, so that thus there would have been a great saving both in the time required for manufacture, and in the weight of merchant iron to be bought. The whole of the lower segment of the cone together with the rings, radial girders and columns, were to have been rivetted with $\frac{3}{4}$ in. rivets, pitched 6 in. apart, with the exception of the lowermost 5 ft. of the cone, and the outermost of the ring girders, where the pitch was to have been reduced to 3 in.

It generally strikes the visitor as an odd arrangement that the stiffening structure should have been put outside the skin of the cone, instead of underneath. This plan, was, however, adopted for two important reasons. First, had the stiffeners been underneath, the slanting rays coming through the windows of the great lantern which serve to illuminate the underside of the cone would have been obstructed everywhere in their path by the concentric ring girders, which would have thrown deep shadows over the entire roof, thus producing a gloomy effect; and second, placed as they are on the outside, they serve to hold the heavy snow to which the country is subject in places, thus preventing it from accumulating unequally, and saving the roof of the ring aisle from the effects of the avalanches which would otherwise be precipitated upon it.

The lower segment of the cone was to have terminated at its upper boundary in a ring platform 20 ft. wide, from which sprang the columns of the great lantern. This ring platform was to have been made of $\frac{1}{2}$ in. plate, and would have been supported as follows by the roof below: 1st, at the inner circumference it would have rested directly on, and been rivetted to, the skin of the cone; 2nd, curved brackets, one resting on each radial girder, would have been rivetted to the underside of the platform, thus supporting it radially; 3rd, it would have been carried at the inner and outer circumference by the railings of the platform, which would have been ring girders 4 ft. in depth consisting each of a web of $\frac{1}{2}$ in. plate, with stiff angle-iron top flanges, while 4th, and lastly, there would have been a precisely similar ring girder running through the central lines of the columns of the lantern, connecting these latter together at their bases, but also extending beneath the platform, so as to bear directly on the skin of the cone, to which it would have been rivetted. This latter ring would have exercised also a most important additional function, namely, that of distributing the weight transmitted by the lantern columns over the entire surface of the cone, instead of concentrating it on the radial girders. Thus it will be seen that the platform was destined to have been a structure of enormous stiffness; the reasons for making it so will be described when explaining the general mechanical principles of the conic system of construction.

The most elementary notion of the great lantern is that of an iron cylinder of $\frac{3}{8}$ in. plate, 100 ft. in diameter, and 30 ft. high, roofed over by a cone whose

angle of slope was, as before, 30° 45′. This cylinder would, of course, of itself have answered admirably in distributing the weight of the lantern uniformly over the entire lower cone; but as the *raison d'être* of the lantern was to light up the interior of the building, it became necessary to cut openings for 30 windows in the cylinder, which windows would each have been 4 ft. wide by 22 ft. in height. It was intended to form these windows in the shape of an oblong surmounted by a semicircle; the lower end of the oblong would have been 4 ft. from the floor of the great ring platform, and the crown of the arch was to have been 4 ft. below the springing of the cone. This arrangement would have left the upper cone supported only by 30 strips of plate iron, arranged round the circumference of a circle, each strip being 6·4 ft. in width; all the strips would have been bound together at the bottom by the uncut portion of the cylinder, 4 ft. deep, while at the top they would have been connected by the series of sheet-iron arches over the heads of the windows. With such an arrangement the supports would have had no stiffness whatever in the radial direction; but this was supplied by taking the iron cut away for the windows, and placing it radially, so as to form, with the first-mentioned strips, columns, whose section was cross-shaped; angle irons were, of course, placed, not only at the crossing, but also at the outer edges of the plates. Any extra stiffness required could, of course, have been obtained by utilising the timbers in which the iron window frames were to have been set. With the exception of these columns, the great lantern would have been a copy, on a small scale, of the lower portion of the roof. The upper ring platform, supporting the little lantern and crowning structure, was also to have been a copy of the great platform, while the design of the little lantern itself was left undetermined until its architectural features had been definitely settled.

Before describing the very simple and inexpensive method of erecting the Rotunda which Mr. Scott Russell proposed to adopt, it will be necessary to give a short account in outline of the theory of the roof; for if the mechanical principles involved be not rightly understood, the proposed method will seem impracticable.

Many engineers, on seeing the plans for the first time, prophesied the certain collapse of the building, some saying that the radial girders would overturn the columns by their thrust outwards, on account of the absence of all tie rods, while others imagined that the weight of the great lantern would cause these same radial girders to tumble inwards, their upper ends describing arcs about the heads of the columns as centres. It is precisely by explaining away these two errors that a correct idea of the theory of the cone can be best given. Abandoning the roof of the Rotunda altogether for a moment, let us consider the equilibrium of a common extinguisher for candles, or, better still, the well-known conic card-board lampshade. Supposing an extinguisher to be mounted on three or four short prisms or columns, although its sides are slanting, it would manifestly have no tendency whatever to overturn these supports. Similarly a lampshade, which is a hollow truncated cone, can be placed on its base on a table, and may have several heavy books placed on its top without showing the slightest tendency either to spread outwards or collapse inwards; and yet neither extinguisher nor lampshade have any internal tie rods whatever. But if we imagine for a moment that the lampshade had a number of radial incisions made in it, the cuts extending from the extreme bottom edge, to within, say, half an inch of the top truncated part, it is evident that in this condition a very small weight placed on the top would cause the whole structure to give way, for the weight acting downwards would cause the radial segments to spread outwards, there being nothing now to hold them together. Hence it is manifest that in the first case the cone was prevented from spreading by the tensile strength of the cardboard in the outer circumference, and not only in the outer circumference, but also in the successive imaginary circles parallel with the outside one, of which circles the cone may be conceived to be built up. Now let us consider the reverse case. Suppose that the radial incisions start from the top edge, and are continued downwards to within a short distance of the bottom edge. Let the cone now be loaded as before at the top; it is evident that in this case the cone will collapse inwards, each radial segment describing an arc of

a circle about its junction with the base line as a centre. Now in describing these arcs of circle, the ends of the radial segments approach nearer to each other; or, in other words, if they were connected together by a ring, they would tend to compress that ring. Hence it is manifest that in the original case the cone was prevented from tumbling inwards by the power of the cardboard to resist compressive strains in the direction of the circumference of the top circle, and not only would the extreme top circle be put in compression, but also a series of concentric circles parallel with it; but we have previously shown that the base ring and the series of circles parallel with it were put in tension; hence the strains in the successive concentric circles of which the cone is made up, vary, under the action of a top load from tension at the base to compression at the top, and consequently pass through the value zero at some particular circle, to find the exact position of which will be shown hereafter. It is perhaps needless to remark that the cone is in compression in the direction of the radial lines of which it may also be conceived to be made up. From the above we see that the usual internal tie rods, common to all modern slanting roofs, are in this case replaced by what may be called circumferential ties, which answer precisely the same purpose, and hence there is no tendency whatever to overturn the columns on which such a roof may rest. But this system of construction has several great advantages over the usual roofs which are made up of several detached pieces; for example, if in these latter one single piece, such as a tie rod, fail, the whole is in peril, but with the continuous conic arrangement nothing can fail till the whole gives way. We can also infer from the above how amply strong the simple cone is to stand all the strains of tension and compression to which it is subjected, and that therefore the radial and ring girders must be looked upon as mere stiffeners, and not as the principal structure. If looked upon from the latter point of view they may even become positive sources of danger; for if all the load be concentrated on them, it is clear that in the case of the Rotunda, there will then be 30 radial lines on the surface of the cone where the strains will be concentrated, and these girders will then tend to flatten out the curved surface of the cone between them, and in fact change its shape from that of a cone into that of a pyramid of 30 sides. This tendency to change of shape will of course be resisted by the stiffness of the rings and their brackets, both of which would of course have to be made extra strong and heavy, in order to resist such serious local strains. It was in order to provide against such a contingency that the columns of the great lantern were designed as they have been described, for it will be remembered that their bases are connected together by a ring girder, which penetrates the plating of the platform, and rests directly on the skin of the cone, thus distributing the weight of the columns and superstructure uniformly over the whole, instead of concentrating it on the 30 radial girders.

It will be remembered that a truncated cone is just as self-supporting a structure as the complete cone, and it has been shown by experiment that its top ring is in a state of compression when loaded. Now the compressive strain is resisted in the case of the Rotunda by the continuous horizontal circular arch 20 ft. in width and 120 ft. in external diameter, which form the great ring platform, and which is stiffened by the three concentric ring girders which have been already described, the outer and inner ones of which also serve the additional ends of forming the railings of the platform.

Enough has now been said in a general way of the theory of this roof to show the practicability of the proposed method of erection, which is now to be described.

Starting with the columns, it was intended that the lowermost 20 or 30 feet of each of these should arrive ready made from the factory. These would have been pushed from off the wagons on which they arrived directly on to the foundation blocks by means of ordinary jacks, and after they had been accurately fixed in position, the remaining portion of the column could have been built up plate by plate with the greatest ease without any scaffolding whatsoever, the men working from the inside in much the same way as they do in Lancashire when building chimneys and houses. If it were necessary to place any workmen on the outside of the columns, this could have been

done with equal ease by suspending a light moveable scaffold from the column itself. The plates, angle irons, &c., would have been lifted into position by means of a rope passing over two pulleys, one at the head of a light movable crane, and the other at the base of the column. The crane would, of course, have been shifted up as the columns grew, and the rope would have been worked, not by a windlass on the ground, which plan would have necessitated one windlass to every column, but by means of horses guided by boys. This system of lifting plates by means of two pulleys, a rope, and a horse walking straight forward on the ground, was employed by Mr. Scott Russell with perfect success and great economy in the building of the Great Eastern, the whole of which ship was constructed in this way. Furthermore, all the columns would have been worked at simultaneously, so as to be finished at the same time, and they would have been steadied by connecting each with its two neighbours by means of an occasional timber beam, which could be removed and applied to other purposes, so soon as the columns were finished. The next operation would have been the connecting the heads of the columns by the two lowermost ring girders, which it will be remembered do part duty for the ring wall, which formed a portion of the original design. This could have been done by making each segment of the ring between two columns on the ground or at the contractor's shops, and then lifting it directly into position by means of the same cranes, ropes, and horses, which were previously employed in the erection of the columns. These latter would thus have been permanently connected with one another, and the timber beams, which had previously been employed to keep them steady, could then have been liberated and used elsewhere. The plating of the roof between the two lower ring girders could then have been put in place. These plates, which were 3 ft. in width over the centre of the columns, and 10 ft. long, were so arranged as to break joint, every second plate of the lowermost tier being only 5 ft. in width, while the remainder were all 10 ft. Each of these plates would have been lifted directly into its place by the same horses and tackle previously described. Each segment of plates between two columns would have been worked at and completed simultaneously, and when rivetted up would have formed of itself a complete self-supporting truncated cone, which would have been as capable of standing alone as the whole roof would have been when complete. The drooping ends of the projecting plates of the tier would, however, have had to be supported in a straight line by attaching them provisionally to beams of wood supported on the heads of the columns. As soon, however, as the next tier of plates were put in position, these beams might have been released and employed in supporting the next series of projecting plates, and so on till the end. The rivetting presented a small difficulty. In order to do this work effectively, it would of course have been necessary to have had men underneath, as well as upon the roof, and this would have been provided for by hanging a light travelling scaffold from rivets with ring heads provided for this purpose, and placed all over the roof at distances of 3 ft. apart.

These hanging scaffolds would have been very manageable, and much safer to work, than those employed in fitting up the gas burners in the Albert Hall. The next thing to have done would have been to erect those portions of the radial girders which are placed on the tops of the columns, and this could have been done by building them up, plate by plate, in the same way as had been done previously with the columns themselves. So far we have got on without the use of a single bit of scaffolding worthy of the name, and, by bearing in mind that each truncated cone is completely self-supporting, we shall see at once how it would have been possible to complete the erection of the remainder of the building without the use of an extra stick. It would first have been necessary to lift up in one piece so much of the radial girders as could have been conveniently done by the old tackle. When these pieces had been rivetted to the ring girder, and the overhanging portion of the column heads, they would have formed projecting semi-girders, amply strong enough to support themselves without bending. Had they been likely to bend, it would have been perfectly easy to keep them straight by connecting their overhanging ends temporarily but firmly together, by means of the same old timber beams; these latter would then have served the purpose of a ring

girder, and the semi-girders could not have drooped except by compressing these beams in the direction of their length, and the lengths of the semi-girders could also have been chosen such that the beams would at the same time have served the purpose of holding up the drooping ends of the next series of projecting plates. When these last had been rivetted together, another segment of radial girders, and another tier of plates, would have been added just as before, and so on till the very end; the ring girders would, of course, have been built up, or lifted in one piece at their proper places, and thus it would have been possible to have arrived at the great platform by the simple plan of making use of that part of the building already completed as a scaffold or basis of operations from which to erect the remainder. Of course it is needless to say that there would have been a squad of men at work between every pair of radial girders, in order to advance simultaneously forward with the whole building in concentric and ever-narrowing rings. The great lantern, with its roof and the crowning structure, could have been easily erected in the same way.

In considering the design and system of erection of this great roof, it must be admitted that it was eminently practical. By the correct application of scientific principles, the engineer was enabled to design a building of 354 ft. in diameter and 250 ft. in height, which would have weighed only 2,000 tons, and cost barely 40,000*l.*, the cost of erection being insignificant, because it was almost identical with the cost of manufacture. The plates would have had to be drilled or punched on the ground in any case, and the erection consisted simply of transporting the materials thus prepared vertically instead of horizontally, and continuing the process of manufacture (*i.e.* the rivetting) in that position high up in the air instead of in some new position on the ground. Now, the cost of vertical transport, thanks to the simplicity of the plan to be adopted, would not have cost more than the horizontal transport usual and necessary in shops. Thanks to the continuity of the conic system, every part of this roof would have helped every other part in withstanding a stress, and so no individual part could have failed till the whole gave way, a state of things which is exactly the reverse of the usual practice. The practical details were so designed that the cost of manufacture would have been a minimum, for, as has been before explained, the immense number of plates of exactly the same size and shape would have introduced a great economy; and, moreover, the whole, with the exception of the ring girders, is straight work of the simplest kind, for the curve of each plate of which the roof is built is so slight as to be practically zero; this of itself causes an immense economy in the manufacture, for the difference in cost between straight and curved work was, with the German contractors, as much as 4*l.* per ton, even before the great rise in prices.

The responsibility of the prompt and accurate execution of the work rested with the Technical Committee of the Exhibition Commission, and the head of this Committee is the Chevalier Engerth, well known in connexion with the Semmering locomotives. It was determined by them that the contractor, whoever he should be, should be allowed free and unfettered choice of the means of erection, in order that he might have no excuse whatever for not finishing the work in the very limited time (10 months) allowed for its execution. Mr. Harkort formed his tender on the supposition that he should erect the building after a plan of his own, which will be described hereafter. He had previously erected a large bridge after this plan, and had consequently a large number of the special tools required in his possession, and was anxious to make use of them; he had, moreover, made arrangements for the supply of the timber necessary for the scaffolding before he knew of Mr. Scott Russell's plan, and for these reasons he determined to persevere with his own method. The choice of means was an unfortunate one, for it necessitated an enormous increase in the weight of the building. Moreover, the work which should have been delivered over completed on the 15th September 1872 was scarcely finished by the 1st May following.

As a sequel to this description of the original design of the great central Rotunda, we may now append three documents, which, together with the original drawings, were issued with the invitations to tender. The first of

these documents is a short description of the drawings, which were four in number, viz., a photograph of the outside elevation, a vertical section of the iron structure, a plan of the same, and a sheet of details in outline. The second document is a summary specification, while the third contains extracts from the general conditions of tender. It must be mentioned in connexion with Document No. II. that the given thicknesses of plates and angle irons in any particular division are the maximum thicknesses of any part of that division. The final adjustment of the dimensions, so as to bring the whole within the specified weight, was to take place, as is expressly stated in Document No. III., after the full-sized drawings had been prepared by the contractor.

DESCRIPTION OF DRAWINGS (see Plate VII., Figs. 2 to 10).

Drawing No. I. presents a general view of the central group of buildings for the great Exhibition of 1873, and also shows the position to be occupied by the great central iron building. But this contract has no reference to the dimensions, forms, or ornaments shown in that group of buildings, and refers solely to the iron portions of the work shown in drawings Nos. II., III., IV.

In all cases throughout this description the exact dimensions are to be taken from the figures of the description, rather than from the scale on the plan.

Drawing No. II. shows the structure of the iron central building in horizontal plan. It consists of two halves, one half shows in dotted lines the woodwork on the ground floor, which is no part of this contract, but also shows the iron girder columns which carry the circular roof.

The other half of the drawing shows the remainder of the iron girder columns, and also the exterior top view of the iron roof. All round the exterior of the columns is shown the iron girder parapet. On the inner edge of the columns is shown a second circular iron girder, and these two girders, with the portion of the iron roof between them, form one continuous circular iron girder, running all round the roof.

The rest of the roof plan shows one-half of the 30 straight girders, which run straight up the conical roof. These 30 straight girders are crossed by five ring girders, each forming a complete circle round the roof.

The roof itself consists of a complete cone of iron plate rivetted and caulked water-tight, underlying all the straight and circular iron girders, but rivetted to them throughout, and forming with the one continuous circular iron girder running round the roof one perfectly united and continuous structure. This represents the first segment of the roof shown in plan, and it ends in a continuous circular horizontal platform enclosed between two iron ring parapets, and divided in the centre by a circular ring, from which spring the columns of the upper or second segment of the roof. These three rings on the crown of the first division are shown by the three thicker circles.

The second stage of the roof springs from this horizontal platform as its foundation, and is carried by columns similar to the lower columns, only smaller and lighter, and 30 in number, not 32. The general structure of the upper division of the roof is similar to the lower, only proportionally lighter and smaller. It also terminates in a similar horizontal ring platform, surrounded by girder parapets, and from its centre springs the third or highest division of the roof; these three girders on the horizontal platform are the three thick lines nearest the centre on the plan.

Drawing No. III. (see Plate VII., Fig. 2) shows the structure of the iron central building in section. The iron structure is shown by the continuous lines. The wooden floor structures are shown by dotted lines, but form no part of this contract. The concrete foundations are shown as shaded blocks, and are no part of this contract. An outer ring of building is indicated by two upright dotted lines, and that also forms no part of this contract.

Springing from the concrete foundations are two upright wrought-iron girder columns. Thirty-two of them carry the roof. The opposite girders from centre to centre are 343·775 ft. apart, and the circle uniting their centres is 1,080 ft. Eng, and forms the circle of construction of the cone of the roof. The distance from this circle to the apex of the cone is 200 ft.

Resting on these columns and firmly rivetted to them is the conical roof with its series of straight girders and ring girders crossing each other, and terminating with the first horizontal ring platform. The drawing shows, resting on the outside of the columns, the first ring parapet; on the inside of the columns a second ring girder, and above a third, fourth, fifth, sixth, and seventh; all of these crossing the straight ridge girders, which run up from each column to the ring platform, which they spread out to and carry. The outer and inner ring parapets are shown guarding the edges of the ring platform.

The section also shows the iron girder columns, 30 in number, which carry the upper division of the roof, and this upper is similar in general structure to the lower division, and terminates also in a horizontal ring platform, from which springs the iron structure belonging to the third division of the roof. The ornamental termination of this roof is no part of this contract.

Drawing No. IV. (see Plate VII., Figs. 4 to 10), shows the details of construction of the chief portions of the ironwork.

A A show the girder columns, 10 ft. × 4 ft. × 80 ft., with the girders resting upon it, and united with it. It consists chiefly of iron plates 3 ft. × 10 ft. (without counting lap), united by iron plates 4 ft. square (exclusive of lap), forming a structure 10 ft. across. E, F, G, show these girders in section, E at the foundation, F higher up, and G where strengthening cross plates occur. The outer and inner faces of the girder are formed of similar continuous rivetted iron plate. The angles are formed of 4 in. angle iron, and the whole is punched, and rivetted at 6 in. pitch.

The continuous circular iron girder running round the top of these columns is shown in its place at A, is shown in section again at H K, and is shown on flat extending from D to D. Its underside is composed wholly of the underplating of the iron roof, and the outer 5 ft. of that plating is all rivetted at 3 in. pitch, while the rest is rivetted at 6 in. pitch. The structure and stiffening of this ring girder are shown at H K.

It is to be observed that this ring girder will first be erected in separate portions on the top of the columns, and then united into one continuous iron girder running all round the roof. But the plates of which it consists will, when the rest of the roof is added, be continuous with the conical roof plating, and the ring and the roof will form one continuous whole. This is shown more especially at B B, C C, D D, where B B is part of the great circle of construction (1,080 ft. in circumference), having the outer ring parapet under, and the first circular girder above it, showing also the tapering plates of which the tapering roof consists as far up as the ring girder C C. At D D are shown also the top plates of the straight ridge girders B C, B C, which run up the cone on the outside from each girder column. The 30 straight ridge girders are shown running up at H, K, L, M, intersected by the ring girders H, K, L, M, and showing the construction and stiffening of these girders. H and K are the ring girders on each side of the construction circle B B. L is the ring girder shown at C C. M and the four others succeed at shorter intervals, and are of proportionally smaller size.

Specifications.

This undertaking is for providing, erecting, and completing, in the Prater at Vienna, a central hall of wrought iron, to form part of a group of buildings for the Exhibition of all Nations in 1873.

Form.—The building is to be circular in plan and cylindro-conical in form. The span from centre to centre of columns is 343·775 ft., or 104·779 metres. The height from floor to crown is 250 ft.

Material.—The building is entirely made of wrought-iron plates, and angle iron, rivetted together in the manner of wrought-iron girders, or iron shipwork. The quantity of this ironwork will exceed 2,000 tons. The quality will be that commonly used in bridges and ships of the highest class, all stamped with the ironmaker's name.

Sizes.—The chief portions of the work consist of wrought-iron plates $\frac{1}{2}$ in. thick, and of wrought-iron angle irons 4 in. × 4 in.

Structure.—The plates and angle iron are rivetted together by single rows

of rivets pitched 6 in. apart. Where the thickness is less, the rivets are proportionally close. (An exception in the pitch of the rivets is that the 5 ft. at the outer edge of the roof is rivetted at 3 in. pitch instead of 6 in.) The longitudinal joints of the plates are lap-jointed, and the ends of the plates are butt-jointed, with a covering plate rivetted on the outside. The whole is caulked watertight.

Work.—Nearly the whole of the work is either dead flat or curved only one way, conic or cylindric. None of the work has to be heated or smithied.

Geometry.—The ruling line for the construction of the building is a circle in plan, of which the perimeter, or circumference, is 1,080 English feet. This is the base of a conic roof of which the radius on the slope is 200 ft. This gives a slope of above 30 deg. to the roof, and a diameter of 343·775 ft. to the base of the cone.

Roof.—The roof of the building rises in stages. The first stage rises along the slope of the cone about 150 ft. and ends in a level platform 20 ft. wide. The second stage rises on a cylinder perpendicularly 30 ft., and thence on the slope 44 ft. to a second level platform ring 10 ft. wide. The third stage rises to the crown of the building 250 ft. above the floor.

Supports.—The supports of the roof are 30 pillars of flat girder work, 80 ft. high, 10 ft. deep, and 4 ft. wide. These are set round the circle of construction, at distances of 12 deg. = 36 ft. The supports and the roof are rivetted together as the rest of the work. Two extra pillars have to be provided and placed.

Foundations.—The foundations of the building form no part of this contract. They will be already prepared up to the level of the floor.

Fittings.—There must be supplied rivets with ring heads on the inside of the roof 3 ft. apart, and also ring bolts of the same description for convenience of erection, completion, and repairs.

This work will be taken either as a whole or in several contracts. For this purpose it is separated into the following divisions :—

First Division.—The first division consists of 30 columns (80 × 10 × 4 ft.). Also two extra columns all of ½ in. plates, and 4 in. × 4 in. angle iron, rivetted as plain girder work. Weight 600 tons.

Second Division.—Thirty transverse curved girders to be carried on these columns, rivetted to them and to each other, 86 ft. × 5 ft. × 12 ft. of ½ in plates, and 4 in. × 4 in. angle iron. Weight 300 tons.

Third Division.—The third division consists of the lower conic roofing. It measures 1,000 ft. round the outer circular edge, and 300 ft. round the inner circular edge, and is wholly composed of ½ in. plates curved one way; lap-rivetted on the straight edges, and butt rivetted on the outside. Thirty ridge girders run up the outside, tapering uniformly from 5 ft. over the centre of the columns. Seven ring girders run round the whole, united with these ridge girders. The two highest of these are made 4 ft. deep, and rise from the top platform, which is a level ring 20 ft. wide. This division consists of ½ in. plate and 4 in. × 4 in. angle iron. Weight 1,000 tons.

Fourth Division.—The fourth division consists of the upper conic roofing, and a ring of columns and arches which support it. The supports, arches, and outer ring, are ⅜ in. plate, and 3 in. × 3 in. angle iron. The roof radial girders and rings are ¼ in. plate, and 2½ in. × 2½ in. angle iron.

The summit ring platform is 10 ft. wide, and has two parapets each 3 ft. deep. Weight 200 tons.

Fifth Division.—This division consists of a cylinder 30 ft. diameter and 40 ft. high, of $\frac{3}{16}$ in. plate, and 2½ in. × 2½ in. angle iron, and terminates in the Imperial Crown.

Extracts from the conditions according to which will be adjudged the concession for the execution of works, and the delivery of materials, for the iron construction of a central hall of wrought iron, which hall is to be erected in the centre of a group of buildings, destined for the International Exhibition in the Prater of Vienna, 1873 :

Term for the Transmission of Tenders.—Those contractors who have received a special invitation to take part in the above-mentioned works and deliveries, are requested to transmit their respective tenders on the 7th day of October 1871, at the latest, to the Director-General of the International Exhibition of 1873, No. 42, Praterstrasse, Vienna.

Contents of Tenders.—The tenderer has expressly to declare in his tender whether he will charge himself with all the works and deliveries specified in the description of the buildings or with only one or more of the five portions into which the work has been divided; he must also specify which of these portions he will undertake. The tender must contain the exact statement of the price per ton in English pounds sterling, payable in Vienna.

The tenderer must sign this extract as a token of his agreement with the conditions hereby communicated to him.

The tender likewise signed and sealed by him is to be forwarded in a sealed but unstamped cover bearing the superscription, "Tender by official request for the International Exhibition of Vienna."

Drawings to be submitted by the Contractor.—Within 10 days at the latest, after having been informed of the acceptance of his tender, the contractor is bound to have made drawings in full size, of all the details of those portions of the works to be undertaken by him and to have submitted them for revision to the engineers. Not before the latter has given his consent to the measures, weights, and dimensions of the materials, as well as the arrangement of the same, will they be taken as definitely settled.

Expenses to be defrayed.—The expense of the transport to Vienna, and especially to the site destined for the erection of the building, the expense of erection, together with all other expenses whatsoever, are to be comprised in the prices tendered, so that the contractor, besides these prices, is entitled to no claims whatever on the funds of the Exhibition.

The contractor is to acknowledge this tendered price to be binding and not to be exceeded, so much so that he must expressly renounce all claims to any additional payment whatsoever, such as compensation for an eventual rise in the price of labour, or material, or for future differences in the rate of exchange.

Custom House Duties on Importation.—On the other hand, the contractor has to pay no custom house duties for the importation from foreign countries into Austria of the materials, manufactures, machines, and tools requisite for the erection of the Central Hall. The general direction will take measures in order that the above-mentioned objects may pass the Austrian line of custom houses without any hindrance or delay.

The Time fixed for the Execution of the Works.—The works necessary for the execution of the Central Hall must be begun and completed within the following terms:

The delivery to the site destined for the building of the first division of the work (the columns) must begin at the latest on the 1st January 1872, and the work of erecting this division must be completed on the 1st of March 1872.

The delivery of the materials for the second portion of the work (the ring girders over the columns) must begin on the 1st of January 1872; and the erection and rivetting must be completed by the 1st of April 1872, at the latest.

As for the third division of the works (the plating for the lower conical roof), the delivery of the materials to the building site is to begin at the latest on the 1st of January 1872, and for the erection, completion, and rivetting of the same an unalterable date is fixed, viz., the 1st of July 1872.

The delivery of the materials to the building site of the fourth division of the

work (the great lantern and the upper conic roof) must begin at the latest on the 15th of May, 1872, and for the erection, rivetting, and completion an unalterable date is fixed, viz., the 15th of August 1872.

As for the fifth division of the works (the crowning structure), the delivery of the materials must begin at the latest on the 1st of August 1872; and for the erection, rivetting, and completion an unalterable date is fixed, viz., the 15th of September, 1872.

Consequences of any Transgression of the Terms fixed for the Completion of the Building.—Should the contractor not fulfil the above-mentioned terms of completion, he has to pay for every day of delay a penalty consisting of 200 florins, Austrian currency, for the first, second, fourth, and fifth divisions of the work, and of 400 florins, Austrian currency, for the third division (the lower conic roofing). The penalty will be deducted from the balance due to the contractor without prejudicing any ulterior measures which may be taken against him for the infringement of the conditions of the contract.

Caution Money.—Within a fortnight from the day when the contractor has received notice of the acceptance of his tender, he has to pay caution money to the amount of 10 per cent. of the cost of the undertaking.

General Consequences of the Non-Fulfilling of the Conditions of the Contract.—Should the contractor in any respect whatever fail to fulfil his contract, the general direction of the Universal Exhibition will have the right, and will be free either to oblige him to fulfil the contract exactly, or to consider the same as null and void, and to dispose of the works and materials at any conditions whatever, at the risk and for the account of the original contractor, or to complete the works under its own direction, and in both cases the general direction of the Exhibition will have the right to cover any damage caused, with the sum paid as caution money, and with all the movable and immovable property of the contractor, and in case that there be no damage, or that the caution money amounts to a larger sum than the amount of damage done, it will have the right to seize that amount as a forfeit.

The Special Consequences of Delay.—These consequences will especially result if during the continuation of the work it be delayed in any way by the fault of the contractor, so as to cause a reasonable fear that the work be not completed in a proper manner at the fixed time, and if the contractor on being requested to terminate the works quickly by the building direction, does not do so within the space of time fixed by the same building direction, and should the works not advance in proportion to the time spent on them, then the building direction will have the right to undertake the works and to manage them itself, at the risk and on account of the contractor, if the latter, being requested by the building direction, do not procure the requisite number of workmen within 48 hours.

Payment.—Payments to the contractor will only be made for completed work. Every month account will be taken of the work completed, and 75 per cent. of the contract price will be paid for the same. The last 25 per cent. of the sum earned will only be paid when the contract has been completely fulfilled, and the building direction has taken possession of the works. There will be no advance made for materials delivered, but not erected.

Decision of Differences according to the Austrian Laws.—The Austrian laws will be referred to in case of any differences, and if anything has to be decided in a legal way, the competent tribunals of Vienna will be referred to.

It will be borne in mind that many reasons, both architectural and technical, conspired together to cause numerous changes in the original design of the Great Rotunda, and we will now proceed to describe the ironwork of the building, as it was actually executed and the reasons for each change, where change occurs, will be amply stated. The principal architectural alterations, with the consequent changes in the ironwork, have already been given, especially so far as they relate to the columns which support the roof, but it will be remembered

that the contractor, for many important reasons, was allowed free choice of any system of erection which he might consider safe and expeditious; and as nearly all the other departures from the original were caused by the peculiarities of the system which he adopted, it will be as well to give a short account in outline of that system, showing, at the same time, how it influenced the weight of each portion of the ironwork.

For the erection of the columns a strong circular scaffold, 26 feet high, was provided, which encircled the entire Rotunda. From the floor of this scaffold were suspended 64 powerful screws, viz., two to each column. These latter arrived in segments, the heads coming first, and the bottom segments last. The heads were then placed in position on the concrete foundations, and were bound together by the wrought-iron girders which form the supports for the great interior gallery running round the base of the cone. To the outer sides of these segments were bolted strong wrought-iron brackets, to which were fastened links suspended from the above-mentioned screws. All the 64 screws were then turned simultaneously by means of long wooden levers, the column heads, of course, following them, and rising for each complete revolution of the levers through a distance equal to the pitch of the screws. This operation was continued till the column heads were raised high enough to allow of the next segments being pushed in underneath and rivetted to them. The wrought-iron brackets were then removed from the heads, and attached to these second segments, the screws being lowered so as to allow of the links being attached to the brackets in their new position. The operation of lifting was then repeated just as before, till the third segment could be thrust in, and in this way the whole of the columns were put in place. In the meantime another great circular scaffolding was being erected in the centre of the building, and was made wide and high enough to allow of the platform of the great lantern being built upon it. When scaffold and platform were completed, the radial girders were brought in segments into the interior of the building, and were deposited and rivetted together on the floor, every one exactly underneath the position which it was eventually to occupy. They were then raised, each in one piece, by means of cranes, to the required height, their upper ends being rivetted to the ring platform, while the lower extremities were made fast to the column heads. Thus much of the description of the erection is sufficient for our present purpose, which is to show that the system adopted caused a vast waste of material.

Referring to the columns, it will be seen at once that, as the screws employed in the lifting them were attached to their outermost sides, and as, also, the centre of gravity of each column could by no possibility coincide with the centre of the screws, but, on the contrary, lay beyond them in a line joining the screws with the centre of the building, it is manifest that each column, during the act of lifting, had a tendency to tumble inwards, its head describing an arc about the point of attachment of the brackets with the links as a centre. This tendency to tumble inwards was opposed by the stiffness of the girders binding all the columns together, but then another evil arose, for the pressure of the screws upon the brackets projecting from the lower ends of the columns caused these latter to bend outwards, and as this tendency was foreseen, it was necessary to provide against any ill effects by giving the columns extra stiffness and strength over and above that which was necessary when once they were in place, and when acting merely as supports loaded by the dead weight of the roof. The consequences of these changes in the mode of erection, and in the architectural arrangements, may be summed up by stating that the weight of the columns was considerably more than doubled. But the ill effects did not stop here: it will be shown hereafter that the extra weight of the columns was the cause of a considerable increase in the strength, and consequently in the weight of the superstructure.

Turning our attention next to the radial girders, it will be remembered that according to Mr. Scott Russell's original plan they had only to play the part of stiffeners to the cone, and exercised no other independent function whatever. Now, however, all this was changed. The girders have been made up in one piece on the floor, and lifted thus into their final positions, and having then been made use of as a scaffolding, by means of which the cone

was built up, it is at once evident that they had to be made strong, and stiff enough—

1. To bear their own weight when standing independently in position.

2. To carry the movable timber scaffolds which were hung to them for the purpose of erecting the cone, as well as the necessary workmen, tools, and material.

3. To withstand the strains transmitted through their upper ends by the weight of the unfinished truncated cone below.

In consequence the light stiffeners of the original plan, whose bottom flanges were the roof itself, had to be transformed into ponderous independent girders, with bottom flanges added to them, and with top flanges and webs of greatly increased strength. The weight of this portion also thus became doubled, and caused at the same time other ill effects, for as the thrust inwards of these girders had to be taken up, or balanced by the resisting power in the great lantern platform, and as the weight of the girders was so considerably increased it is clear that extra metal had to be put into the platform in order to reduce the stresses to their former intensity. In fact, the extra thrust thus generated was provided for by the addition of a separate ring connecting the upper extremities of the radial girders.

Let us now consider the effects of these three separate increments of weight, in the columns, the radial girders, and the great lantern platform, on the coping ring, surmounting the column heads, at the base of the cone. It has been seen that this ring had not only to take up the thrust outwards of the cone and its stiffeners, but had also to be strong enough to carry suspended from it any one of the columns whose foundations might sink. Now we see that the thrust outwards was greatly increased by the extra weight of the radial girders, while the work to be done by the ring, in carrying a column, was more than doubled, for the weight of the column itself was, as has been stated above, more than doubled. Consequently, this ring, too, had to be vastly increased in weight, in fact, it was made into a regular box girder, by covering in the top between the first and second ring girders with $\frac{1}{2}$ in. plate; the joints of the plates had also to be doubled in strength, and the stiffeners for the rings, which, it will be remembered, were formerly mere triangular brackets, were now enlarged into regular diaphragms or bulkheads, occupying an entire cross section of the box ring. Similar changes to those mentioned above had, for like reasons, to be introduced into the roof of the great lantern, and when it is remembered that the gallery, 1050 ft. long at the heads of the columns, in the interior of the building, was an afterthought of the architects, not included in the original estimates of the engineer, it ceases to be a matter for surprise that the total weight of the construction was nearly doubled.

We will now describe the principal portions of the ironwork in detail, beginning with the columns which support the roof. The latter are, for reasons which have been before explained, box-shaped in section, their dimensions being,—height along central axis = 80 ft. $0\frac{5}{8}$ in., depth = 10 ft., and width = 4ft. $0\frac{3}{4}$ in. It must be remarked that the boxing is not continuous throughout, for seven bays or openings are left in each of the 10 ft. sides. The dimensions of these openings are 5 ft. $11\frac{1}{16}$ in. × 5 ft. 11 in. Each column is stiffened by eight angle irons, which run from the foundation plate to the head, viz., one in each of the four corners of the box, and one skirting each edge of the openings (see Plate VIII.). There are 16 bulkheads of angle-iron lattice-work put in as horizontal stiffeners, viz., one bounding each horizontal edge of the bays or openings. These principal bulkheads occupy the whole horizontal section of the box, but in addition to them, there are 14 lesser ones, also of angle-iron lattice-work, which are situated generally at the middle of each of the bays, and occupy only so much of the section of the box on either side as is left over, after the central portion of the sides has been removed to form the opening. The head and foot of each column are made stiffer than the remaining portion, the former by being boxed in completely for 11 ft. $3\frac{1}{4}$ in., measured along the central axis, and by the addition of a central diaphragm 3 ft. $3\frac{9}{16}$ in. deep, while the latter is not only completely boxed for the first metre in height, but is also provided with two transverse vertical plate bulkheads which reach from the foundation plate to the bottom edge

of the first opening. On the sides of the columns at a height of 46 ft. 3½ in. from the foot are placed plate-iron brackets which serve as springings for the arches, which form such a prominent feature in the decoration of the interior of the building. The head of each column is inclined upwards and inwards at an angle of 30° 44′·428, and the angle between the cone and the inner side of the column is rounded off by means of a curved plate bracket. All the plates are ⅜ in. thick, with the exception of the foundation plate which is ½ in. The angle irons are 3 1/16 in. × 3 1/16 in. × ½ in., and wherever practicable they are made up in lengths of rather more than six metres. The rivet holes are invariably 1/16 in. in diameter. The horizontal joints of both plates and angle-irons, though in compression, are rivetted, as a precaution against bad workmanship, on the supposition that all the strains would be transmitted through the rivets. It was fortunate that this precaution was taken, for workmanship in Germany does not approach the English standard of accuracy.

We next come to the great coping or tension ring which surmounts the heads of the columns binding these latter together, and serving not only as a wall on which rests the lower edge of the cone, but also as the final resistance to the outward thrust of the roof.

The vertical section of this ring is box-shaped, and its dimensions are:

Length along central axis - -	1,080 ft. 2 5/16 in.
Top and bottom sides of box - -	11 ft. 7⅜ in.
Ends of box each - - -	5 ft.

The bottom of the box consists simply of the lowest ring segment of the cone (see Plate IX.). The upper side is also the lower segment of an exactly similar and parallel cone, the two remaining sides stand at right angles to the roof, and are consequently the lowest segments of two cones pointing downwards, whose apices lie in the same vertical line with the apex of the original, and whose angles of slope are the complements of the angle of slope of the original. They may therefore be called complementary cones. All four sides of the ring girder are available in taking up the tension generated by the outward thrust of the roof, while only the two shorter sides play the additional part of walls. Each segment of the girder between two columns is stiffened by three radial bulkheads of the same shape as the section of the box, and over the columns themselves the lower ends of the radial girders fulfil a similar function. The two segments at the main axis of the building are stiffer than the others, for it will be remembered that here, the two radial girders have no columns to rest on, and consequently rely for support at their lower ends on the rings standing at right angles to the roof. This extra stiffness is given by simply adding a third ring segment to the two already existing. This latter ring is situated exactly over the centre of the columns, and more than supplies the extra carrying powers needed. Manholes closed by doors to admit painters and repairers, are provided in the upper side of each segment of the box, while similar holes, though without doors, are formed in each of the stiffening bulkheads.

All the joints of each of the four sides which lie in vertical radial planes are made flush, and are rivetted with double covering strips, and fourfold rows of 1/16 in. rivets pitched 3 1/16 apart; the circumferential joints of the lower side are, however, in compression, and have merely single strips, and rivets pitched at 5⅛ in. The joints in tension in each of the four sides are so arranged as to break joint in the manner usually practised in boiler making; for example, the plates in the lowest of the two rings standing on the columns have not got their joints in the same vertical radial plane with those in the upper ring, and similarly the junction of the two plates in the lower side of the box corresponds with the middle of a plate in the upper side, the same arrangement holds good with the circumferential angle irons. The plates in the upper and lower sides of the box are ·472 in. in thickness, while those in the two other sides and in the bulkheads are ·31 in. The covering strips are 5/16 in., and the angle irons are for the most part 3 1/16 in. × 3 1/16 × ⅓ in. All the rivets are 1/16 in. in diameter without exception. All the stiffening rings of the lower cone, with the exception of the uppermost one, are like the two just described, simply the lowest ring segments of so many complementary cones. Otherwise there is nothing remarkable about them, for they are

ordinary flanged plate girders whose lengths are governed by their position on the cone, and whose depths are so arranged that each ring can fit between the top and bottom flanges of the tapering radial girders. Their bottom flanges are rivetted only to every second plate of the cone, the three spaces between the flange and the remaining plates being left as passages for the rain water which would otherwise accumulate in ring pools at the foot of every one of these girders. Each segment of the ring between two radial girders is provided with three triangular brackets to strengthen its hold on the cone. The top ring, which together with the platform of the great lantern forms the final resistance against the inward thrust of the roof, is different from the other rings in being cylindrical in shape, that is to say, instead of standing at right angles to the slanting side of the roof, it stands vertically upwards, making an obtuse angle with the latter. It is also stiffer than the others, for it has to take up a considerable compressive strain. It is 35·55 in. in depth, of which amount 8·38 in. rises above the level of the platform. Where the flooring plates of the latter intersect the ring, it is stiffened by four angle irons arranged in the form of a Greek cross :

that is to say, one angle iron lies in each corner formed by the intersection. The lower flange is formed of one large angle iron, and two obtuse-angled gorget plates which serve to connect the ring with the cone thus :

The dimensions of this last angle iron are ·55 in. × ·55 in. × ·63 in., and the rivets employed in it are ·90 in. in diameter. The other angle irons are $3\frac{1}{16}$ in. × $3\frac{1}{16}$ in. × $\frac{1}{2}$ in. in dimensions, the plates are all $\frac{5}{11}$ in., and the remaining rivets all $\frac{1}{16}$ in.

Passing from the ring to the radial stiffeners it is first to be observed that these latter are simple flanged plate girders, inclined in position and tapering in shape. For the most part their lower ends rest on the heads of the columns, and their upper ends terminate in the cylindric ring just described. The lowermost segments contained within the coping ring are oblong in shape, but the remaining portions taper from a depth of 5 ft., at the columns to about 1 ft. 10 in. at the top.

These depths it may be mentioned are measured at right angles to the roof. The top flange which varies from 26 in. to $15\frac{3}{4}$ in. in width, consists of two $\frac{3}{8}$ in. thick plates rivetted together, and is attached to the web by means of two angle irons, whose dimensions are $3\frac{1}{16}$ in. × $3\frac{1}{16}$ in. × $\frac{1}{2}$ in. The lower flange, deriving as it does considerable strength from the skin of the roof, is not made so heavy as the upper one, and consists merely of the two usual angle irons, and a plate $18\frac{3}{4}$ in. in width, and $\frac{7}{16}$ in. thick, rivetted to their lower surface. The web is formed of plates ·51 in. in thickness, and all the joints which are in compression are formed on the supposition that the strains may pass entirely through the rivets. Attached to the upper end of each radial girder is a triangular bracket (see Plate IX), one of whose sides is horizontal. These brackets form the supports of the platform of the great lantern, the plates of which are rivetted to the horizontal side of the triangle. The columns of the great lantern are also supported directly by the brackets. An exactly similar support, consisting of the upper end of a radial girder combined with the above mentioned triangle, is attached to the roof and the platform

midway between each column. Thus the platform which is 13 ft. $1\frac{9}{10}$ in. wide is carried by 60 supports in the radial direction.

Let us now proceed to the upper portion of the building, which is in principle a copy on a reduced scale of the portion just described, differing, however, from it in many important details. The upper cone, like the lower one, stands on 30 columns, each 34 ft. $4\frac{1}{10}$ in. high. These latter are not, however, all of the same dimensions in plan, for every third one is made considerably larger than the remainder. The reason for this arrangement was simply an architectural one. It was found that if the columns had all been of the same size, their proportions of width to height, when arranged in any order of architecture, and clothed with the traditional decorations would have been such as to restrict the width of the windows very materially. It was impossible to permit this for the supply of light would then have been seriously diminished. Hence it was determined to arrange the columns in such an order that the windows could be maintained at their full size. This was effected by accenting every third column, and diminishing the others in a manner which will be understood at once by referri.. to the plates (see Plates X.; XI.). One of the consequences of this alter. on is that the axes of the smaller columns do not stand directly over the axes of the radial girders. This, however, is no serious misfortune, for the difference is not sufficient to be perceived by a spectator.

The larger of the two classes of columns are 10 in number, and their dimensions in plan are 5 feet × 2 feet. They are arranged exactly like the great columns of the lower roof with their long sides in the radial direction. Each column is a simple lattice girder, the two flanges of which correspond with the two narrow sides of the columns, while the two lattice webs answer to the wider sides. The narrow sides do the principal carrying work, and consist each of a single plate ·236 in. in thickness, and two angle irons whose dimensions are 2·36 in. × 2·36 in. × ·275 in., while the lattice work has merely to prevent these two sides from spreading. The wider sides are divided into seven panels, each of which is filled up by two diagonals of bar iron, and the panels are further separated from one another by horizontal bulkheads of crossed angle irons occupying the section of the column. The head and foot are stiffened by the addition of central diaphragm plates.

The smaller columns 20 in number are exactly the same length 34 ft. as the larger ones, and are also of a precisely similar construction. The principal difference lies in the size of the cross section, which in the present case is 3 ft. $3\frac{3}{8}$ in. by $15\frac{3}{4}$ in. In both classes of columns, the thickness of the plates employed is ·236 in.

The size of angle irons	- -	2·36 in. × 2·36 in. × ·275 in.
The size of rivets	- - -	·590 in.
The ruling pitch of rivets	- -	4·72 in.

The heads of the columns are connected together by a box ring exactly similar in principle, and differing only in size from the one employed in the lower roof. In fact the whole of the remainder of the structure, as far as the platform of the upper lantern, is only a reproduction on a smaller scale of what has been already described. As each portion of the structure is illustrated by detail drawings, it will not be necessary to go further into the subject here, and we can pass at once to the small lantern which with its dome forms the crowning structure of the whole work.

This portion of the building like the remainder is similar in plan, and consists of 10 columns, each 29 ft. $9\frac{1}{4}$ in. in height, connected together at the top by a simple lattice work, and surmounted by as many curved girders, which constitute the ribs of the dome. These curved girders instead of intersecting in the central point of the building are made to terminate in a cylindric ring—an arrangement precisely similar to that which was adopted with the radial girders of the upper and lower cones. In the present case this ring forms a kind of platform on which is erected a crown in sheet iron, richly gilt, made after the model of the Imperial crown of Austria.

The whole of the iron work of the building has now been described, with the exception of the skin of the cone itself, and it is so simple in construction that there is very little to say about it. It is formed of tapering plates of iron

·472 in. in thickness at the base of the lower cone, and ·433 in. at the top. All the longitudinal joints in the radial direction are lap rivetted, with ·708 in. rivets pitched 6·29 in. apart, excepting those at the very bottom between the two coping rings, where the tension being greatest the joints are rivetted with covering strips, and fourfold rows of rivets pitched $3\frac{5}{16}$ in. apart. The circumferential joints, being in compression, butt, and are rivetted with covering strips (see Plate XII.).

The ironwork, or bones, as they may be called, of the Great Rotunda have been described in the preceding article, but, in order to complete the account of the building, it will be necessary to show how the plain unornamented construction of the engineer was transformed into a monumental work of architecture.

It will be remembered that the outside of the building is completely surrounded by a ring annex above the roof of which the columns of the Rotunda proper rise to a height merely of 6 ft., so that only a very small portion of the exterior below the base line of the cone is visible at all (see Plates XIII., XIV.), and as the cone itself, with its radial and ring girders, is incapable of much adornment it will be seen at once that the two lanterns naturally became the subjects of the richest decorations; in fact, they look from the outside like a profusely adorned circular temple standing on an enormous pyramidal pedestal, which latter is, of course, the lower cone. In the interior, however, it is widely different, for here every portion of the building is capable of, and has, indeed, received lavish decoration. As, however, the time which was left over after the completion of the ironwork was very limited (only four months), it was not possible to do the finishing in a very permanent fashion. The work, as executed, will nevertheless, as may be seen from the following description, last for several years, and can then be either renewed in the same style, or be made really lasting.

The general style of architecture, so far as it belongs to any system, may be called Roman Renaissance, and consists of a combination of pilasters, pillars, and arches, profusely enriched with cornices, mouldings, and other ornaments in relief; in the interior, in addition to the work in relief, there is a considerable amount of ornament coloured in neutral tints. The underside of the cone is covered with a tarpaulin of canvas hung in truncated-shaped segments, viz., one such segment between every pair of radial girders. The canvas is adorned with large figures of angels, painted in gold and colours, and has, moreover, at the upper and lower edges a deep belt of ornament richly designed. The tarpaulin terminates both above and below in circular mouldings, which give a handsome finish to the base of the cone and the opening into the great lantern. The details of the construction of the different ornaments are as follows:

Each column is arranged so as to appear like a great rectangular pillar standing on a pedestal, and supporting a large entablature and cornice, on which latter apparently rests the cone. The narrow or 4 ft. sides of the columns appear consequently as pilasters, and are surmounted with Corinthian capitals; while the longer 10 ft. sides are each broken up into two pilasters, which carry the springings of the arches connecting the columns. In order to attach these pilasters, &c., to the ironwork, the following arrangement has been adopted: The columns are all encased, from head to foot, in timber frames, so arranged that each angle of every pilaster is formed by one of the balks of the frame. At the foot the framework is of course spread out so as to form the pedestal. The arches likewise are formed of timber, while the spaces above them, and between the columns, are filled in with stout frames, so constructed as to stiffen these latter, besides forming the foundation of the plasterwork. The whole of the framework when in place was covered with a light boarding, to which was nailed a network of reeds, the use of these latter being merely to form a rough surface to hold the plaster. All the pilasters, the mouldings of the arches, and the ornaments in relief of every kind were then formed in the usual manner of the very best plasterwork, in the manipulation of which the Viennese workmen from long experience are peculiarly skilful. The large cornice surrounding the column heads was, however, formed in a rather different manner. It was found that if this latter

were made according to the usual proportions it would form a ledge deep enough to be made use of as a gallery which would accommodate 1,400 persons. Accordingly it was determined to employ it as such. As a gallery of this nature would occasionally have to undergo very severe loads, it was necessary to form the framework of iron girders instead of wooden frames; moreover, as a plaster cornice would soon be knocked to pieces by the vibrations caused by a tramping multitude overhead, it was determined to make it of zinc instead of cement. This painted zinc cannot be distinguished from ordinary mouldings, and has, moreover, the advantage of being much the more durable of the two. Another reason which rendered the use of this material absolutely necessary, was that it was possible to make all the ornaments in it during the progress of the erection of the ironwork, so that nothing remained after the completion of this latter but to fasten the ready-made zinc-work in place, an advantage which cannot be over estimated when it is considered how short the time was which was left over to complete the building. The circular mouldings round the base and the upper edge of the cone are also formed of zinc supported by wooden ribs, which latter are fastened directly to the skin of the cone. Between these two latter mouldings the canvas segments are stretched, and are attached to the roof by means of the ring-headed rivets provided for that purpose. The canvas is of its natural colour (a light golden grey), and on it are painted all the decorations by means of stencil plates, the prominent colours being blue, brown, and gold. There is so much of this latter material employed all over the roof, that, taken in conjunction with the colour of the canvas, the whole had much the effect of a gilded ceiling with ornaments in colour. It will perhaps convey an idea of the size of this building when it is stated that the angels represented on the canvas are about 21 ft. long, while such figures as cupids are about the size of an average human being.

The spaces between the columns were left open, so as to form everywhere a free passage into the ring annexe, much in the same way as with the aisles and nave of a cathedral; an exception to the above rule is, however, to be found in the four spaces between the columns, which are planted close together. These latter spaces are occupied by the staircases and lifts which provide access to the first gallery. The staircases themselves and the lifts are hid from view by means of handsome grillages of wrought iron richly gilt, which stretch between the fronts of the columns. These grillages serve at the same time to light and ventilate the staircases (see Plate VI., Fig. 1).

The fronts of the pilasters, the spaces above the haunches of the arches, and the entablature are all richly adorned with what look like fresco paintings; they are, however, not frescoes, but oil paintings prepared in neutral colours on ordinary picture canvas and mounted on frames. These frames had merely to be fastened in place so soon as the plasterwork was finished, and in this way the whole of the painted decoration was mounted in a few days, for the designs had all been prepared and executed, like the zinc cornices, during the progress of the ironwork. To have executed the work in fresco, in the ordinary way, would have taken some months after the plaster had dried.

Passing next to the great lantern, it will first be noticed that the arrangement of the columns and arches differs somewhat from the plan employed below. Here every third column is made to appear like a rectangular pillar, on whose capital rest the entablature and cornice which skirt the base of the upper cone, and from whose *sides* spring the arches which connect all the columns together, while the intermediate ones look like short cylindrical pillars, on whose *heads* or *capitals* rest the abutments of the above-mentioned arches. Here for the sake of durability all the ornamented work is wrought in zinc, backed as before by stout timber frames. In other respects the great lantern and its roof is finished in much the same style as the lower part of the building. The whole of the decoration of the little lantern is also formed of zinc, with the exception of the crown which rests on its summit. This latter is a most elaborate piece of workmanship, being an exact reproduction, on a magnified scale, of the imperial crown of the empire. It is over 15 ft. in height, and is formed entirely of thin sheet iron richly gilt, all the gems of the

original being reproduced with great care in coloured glass. The crown contains more than 1,100 of these reproductions of precious stones, which are so formed as to glitter with great brilliancy in the sunlight.

There remains now nothing to be described but the floor of the building, which latter, however, should not escape attention. The level of the floor of the greater portion of the Rotunda proper is 4 or 5 ft. lower than that of the remainder of the Exhibition, so that the floor of the ring annexe and the outer ring of the Rotunda itself form a great circular terrace, which communicates with the sunken portion by means of a ring flight of steps. The exact centre is occupied by a circular fountain of exquisite workmanship, which was one of the French objects of exhibition. The effect of this arrangement is very good, for the spectator standing on the terrace has the benefit of the always pleasing bird's-eye view of a sunken garden, with its central fountain, its trees, and costly objects of exhibition scattered about; while to any one standing down below the building is rendered more important, and its general effect is greatly enhanced, by the fact that it stands on an elevated terrace approached by a flight of steps.

Before closing this account of the building, it will be as well to notice several important points, such as its fitness to withstand the effects of the weather, the lightning and ventilation, and the means of communication.

With reference to the weather, a building should be so constructed as not to be injured either by lightning, by the effects of changes of temperature, by snow, or by rain. It will presently be seen that the Rotunda is amply provided against the ill effects of all such contingencies, but we must defer the consideration of this and the other points just mentioned.

We have now to consider the points mentioned at the close of our last article, and may take them in the following manner:—

1. *Lightning.*—Lightning is only injurious to a building when the path of least resistance of the electric fluid lies through masses of non-conducting material, such as stone or brick. For example, the lightning may strike some attracting portion of a house; on its way to the ground it will probably fly to some of the large conducting bodies; such as water-tanks, fire-grates, &c., contained within the walls of the building; but before it can get to these latter it has to pass through non-conducting materials, which, as it cannot traverse by the ordinary process of conduction, it necessarily smashes up on its way, thus doing considerable damage, and often even causing total destruction. The use of a lightning conductor is then twofold. 1st, it provides a point of greatest attraction to the fluid, so that the lightning will be sure to strike the conductor instead of any other portion of the building; and 2nd, it furnishes a line of least resistance between the point struck and the ground, in order that the lightning may pass along this line without doing any damage by crashing through resisting or dialectric material. But in the Rotunda all such precautions are absolutely unnecessary, for the building contains no resisting material, but it is, on the contrary, one vast conductor, such that the lightning may strike it anywhere, dissipate itself over its surface, and then, finally, find its way by one or more columns to the ground without doing any damage to anything.

2. *Changes of Temperature.*—Supposing the building to have been erected at the normal temperature of 10 deg. centigrade, let us examine the effects of any violent increase of heat. Wrought iron when heated expands ·000012204 of its length for every degree of increase of temperature on the centigrade scale. Hence, the outer ring which is in round numbers 1110 ft. long would, under the influence of a rise of temperature of 50 deg. cent. (=to a total temperature 60 deg. cent. or 140 Fahr.), expand by an amount =8·13 in. That is to say, the radius of the base of the cone would be increased by about 1·3 in. or, in other words, the tops of the columns would be bent out to the same extent, a distance which is not worth considering when it is remembered that the length of a column is 80 ft. At the same time, the ring boundary of the upper edge of the lower cone, and also each of its radial elements, would elongate by certain known quantities, and from the conditions thus obtained it is perfectly easy to draw the shape of the roof at any given temperature.

3. *Snow and rain.*—It was necessary to provide such a construction that the

snow would, when it fell, be retained symmetrically distributed over the surface of the roof, and after it had melted, would pass off at once like rainwater. Had the first precaution been neglected, it would probably have resulted that the snow, under the influence of the wind, would have accumulated unequally on certain portions of the roof, thus introducing local strains, and also when it began to thaw it would have fallen in very considerable avalanches on the roof of the ring annexe below. Both these ill effects were provided against by putting the stiffening structure above instead of below the skin of the cone. The snow when it thaws is allowed to escape underneath the bottom flanges of the ring girders, which, as has been before explained, are only rivetted to every second plate of the roof, the intermediate spaces being left perfectly free; the same arrangement provides for the rain. The water can thus flow freely down the roof till it reaches the coping ring, where it accumulates, and is carried off through large zinc pipes which descend through the columns, and, finally, empty themselves in the earthenware drain pipes which form part of the general system of drainage of the Exhibition. In order to prevent the water on its way down the roof from penetrating between the plates, all the joints of these latter are securely caulked with lead and are painted over.

4. *Lighting.*—In arranging the windows of a great public building, the object should be as far as possible to throw the rays of light on the different portions of the interior, and not into the eyes of spectators themselves; for every object is seen clearly just in proportion as it is well lighted, but if the eye is exposed to the direct rays of the sun it is prevented from seeing anything. This object is in the present case fully attained as follows: There are two great sources of light provided, viz., the windows of the great lantern and those of the ring annexe. The former are directly available in illuminating the underside of the cone itself, the inner faces of the columns, and also to a considerable extent the floor of the building, while the latter throw a suffused and equal light over the whole of the lower structure. No direct rays of the sun can stream through these lower windows far into the centre, for they are shielded at all except high elevations by the quadrangular block of buildings which surround the Rotunda, and the higher the sun is in the heavens the more nearly does the angle of slant of its rays approach a right angle, and consequently the smaller is the distance to which these latter can penetrate through a *side* window.

The only case in which a direct sun ray coming through the upper windows can strike a spectator standing on the floor of the Rotunda is when at one particular time in the day a line drawn through the windows of the lantern, from a spot situated of course in the neighbourhood of the circumference of the ground plan, will strike the sun. This happens once during the day for a short time, with the proportions of size of lantern to size of ground plan adopted in the present case. Of course if the diameter and height of the lantern were increased, we should have a larger portion of the floor directly illuminated for a longer period in the day, and *vice versâ*, by diminishing the size of the lantern we should be enabled to shut out the direct rays altogether from this portion of the building. The underside of the roof can be illuminated to any extent between certain limits by increasing the size of the lantern. The maximum effect is attained when the slant side of the cone intersects the top of the lantern windows, and forms with the straight line drawn from the base of the cone to the foot of the windows the greatest angle possible. In practice, however, it would be impossible to determine the size of the lantern thus, for the architectural appearance of the building would be completely marred.

5. *Ventilation.*—It was explained in a previous number how the roof, when heated by the sun, would cause the air immediately beneath it to ascend; and this air escaping through the open windows of the lanterns, it would naturally be replaced by fresh supplies drawn from below. Thus the action of the conic roof resembles that of a chimney, and is sufficient not only for its own ventilation, but also for that of the entire Industry Palace.

Means of Communication.—Access is gained to the first gallery and the great lantern by means of two lifts and as many staircases, enclosed in the spaces between the columns immediately right and left of the main axis of the building. Near the tops of the columns a second staircase branches out from

the main one. This branch staircase leads out to the roof of the ring annexe, and thence passes right up the side of the cone as far as the platform of the great lantern. The main stairs, however, land on the first gallery. A similar plan is adopted with the lifts. The public were not allowed to go up higher than the great lantern platform; but for the service of the building there will be provided an iron ladder up the side of the lantern, together with a second staircase resting on the top cone.

The general principles of the continuous conic system of roofing are easy to understand, though the determination of the strains with rigid mathematical accuracy is a little complicated. The whole subject of untied roofing of which the cone is a special case, is too large to be treated generally in this review, the length of which is limited, hence we must content ourselves with special instead of general investigations, and postpone to some future occasion the treatment of the subject matter in a comprehensive way.

In order to know by experiment how a cone is destroyed by a load, which may either be placed on its summit or distributed over its surface, let us reconsider the pasteboard lampshade already mentioned. Such a lampshade is usually a truncated cone, and if it be placed on a level table and loaded with books or other convenient weights, it will be found that a certain load, proportioned of course to the strength of the cardboard, will destroy it by tearing the bottom edge in a radial direction, and by crushing in the top. This experiment shows that the bottom edge is in a state of tension, while the top is in compression, a state of things which we shall see to be the case from the following considerations. Let us first take the case of an ordinary timber truss of the shape shown in Fig. 1, whose weight including

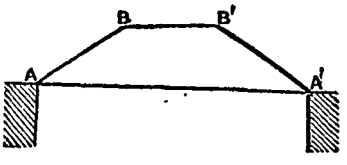


Fig. 1.

the load is W, and the angle of inclination of whose rafters is α. Suppose the load so distributed that its centre of gravity is half way up the rafter on either side, then we should have the following external forces acting on the truss, viz.:

1. The reaction of each abutment acting upwards $= \frac{W}{2}$.

2. The half weight $= \frac{W}{2}$ on either side acting vertically downwards through the centres of gravity.

Each of these latter forces can be replaced by two others, viz.:

One acting downwards at the abutment A $= \frac{W}{4}$.

And the other acting downwards at B also $= \frac{W}{4}$.

Hence finally we have at the abutment a force $= \frac{W}{2} - \frac{W}{4} = \frac{W}{4}$ acting upwards, and another force at B $= \frac{W}{4}$ acting downwards. Hence the effect of the force at A in the direction of the rafter A B $= \frac{W}{4 \sin. \alpha}$, and resolving this latter in the direction of the bar A A', we have a force of tension in this latter $= \frac{W. \cos.}{4. \sin. \alpha} = \frac{W}{4} \cot \alpha$.

Similarly the force at B acting downwards produces a stress of compression also $= \frac{W}{4} \cot. \alpha$ in the bar B B'.

The rafter A B is of course subject to a compression which at the foot amounts to $\frac{W}{2 \sin. \alpha}$. We have thus got all the absolute stresses, and to find their intensities in any bar, we have to divide the whole stress in that bar by its cross section, and we thus obtain the intensity in so many tons or pounds per square inch.

Let us now advance from the truss to the truncated cone standing on a smooth and level plane. The method of investigation is precisely similar. The external forces are :

1. The reaction of the level plane equal to the weight of the cone $= W$ acting upwards at the base ring.

2. The weight of the cone $= W$, acting downwards through the ring connecting the centres of gravity of the [ ]-shaped elements which form the cone.

This latter force may be replaced as before by two components, one acting round the base, and the other round the top ring, these two forces being of course inversely proportional to the distances of the two rings from the centre of gravity. Thus, if the cone were a complete one, the centre of gravity would be situated at one-third of the length of the slant side from the bottom edge. Hence the two forces to replace the original weight would be $\frac{2W}{3}$ acting downwards round the bottom ring, and $\frac{W}{3}$ also acting downwards at the top, and the resultant of the forces at the bottom would be $W - \frac{2W}{3} = \frac{W}{3}$ acting upwards uniformly round the base. If the cone be truncated, the position of the centre of gravity lies somewhere between the points of bisection and trisection of the slant side, the exact point depending on the angle of inclination, and the length of this side. Let us for the present then call that component of the whole weight which acts round the base $\frac{W}{n}$; then the resultant of the outward forces at the base $= W - \frac{W}{n}$. The effect of this force estimated in the direction of the slant side of the cone is $\left(W - \frac{W}{n}\right)\frac{1}{\sin \alpha}$, and resolving this latter force horizontally in the direction of the radii of the base ring, we get $\left(W - \frac{W}{n}\right) \cot \alpha =$ to the total horizontal radial thrust outwards at the base of the cone, and similarly $\left(W - \frac{W}{n}\right) \cot \alpha =$ the horizontal radial thrust inwards at the top. If, now, the cone were divided up by a number of radial slits, and were held together merely by a ring at the bottom, and another at the top, it would be easy enough to find the stresses in each of these two rings. For let the annexed, Fig. 2, represent the base ring, the radial lines with arrow-heads representing the directions of the horizontal

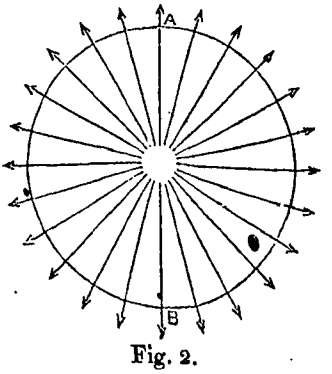


Fig. 2.

thrusts outwards, which act uniformly round the circumference, thus tending to stretch, and put it into a state of tension. How to find this tension is well understood by boiler and pipe makers. It is as follows :—

Conceive the ring divided into two halves at A and B. The total horizontal thrust is, as was proved above,

$$=\left(W-\frac{W}{n}\right)\cot.\,\alpha,$$

where n lies between 2 and 3.

Hence the intensity of the thrust per unit of circumference is—

$$\frac{\left(W-\frac{W}{n}\right)\cot.\,\alpha,}{2\pi r}$$ where r = the radius.

And the sum of these thrusts on one side of the diameter, A B, is—

$$\frac{\left(W-\frac{W}{n}\right)\cot.\,\alpha.}{2\pi r}\times 2r=\frac{\left(W-\frac{W}{n}\right)\cot.\,\alpha.}{\pi}$$

Now this thrust outwards is resisted by the strength of the metal at A and B. Hence the stress at

$$\text{A or B}=\frac{\left(W-\frac{W}{n}\right)\cot.\,\alpha}{\pi 2}.$$

And the intensity of the stress per square inch is equal to

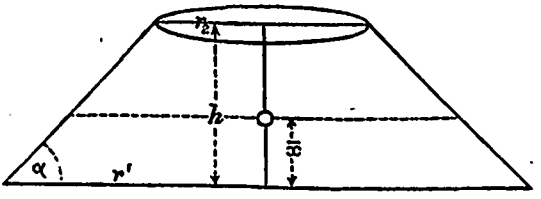
$$\frac{\left(W-\frac{W}{n}\right)\cot.\,\alpha}{2\pi},$$

divided by the number of square inches in the cross section of the ring at A or at B. In a similar manner the stress of compression in the top ring may be found to be exactly equal to the stress of tension in the bottom, and its intensity may be found in the same manner.

But now we come to our first great difficulty, for the supposition on which the above demonstration is founded is untrue, the cone not being divided by radial slits into an infinite number of segments, held together merely by rings at the top and bottom, but it is, on the contrary, perfectly continuous throughout the successive rings of which it may be conceived to be built up, each taking a certain share of the tension or compression, as the case may be. Of course the total horizontal thrust both inwards and outwards remains the same, for the weight and angle of slope of the cone have not been altered; the only trouble is therefore to determine the intensity at any point of the stress of tension or compression generated by these horizontal thrusts. If we conceive the whole stress of tension, say concentrated at the bottom of the cone, we have no choice but to consider it as concentrated in the extreme bottom fibres, and as these have a cross section = zero, it is evident that the intensity of the stress $=\frac{\text{whole stress}}{\text{area strained}}=\frac{\text{something}}{\text{nothing}}=$ infinity—that is to say, a weight, however small, would tear the cone—a condition of things which we know from experience to be untrue. When once we are driven to admit that the stress is not all concentrated in the extreme top and bottom, we are left in doubt as to the intensity we seek for, as we do not know at first sight how to divide the total stress among the successive rings. To determine this point is the object of the following investigation. The method employed is:—first, to determine the total horizontal thrust at the base as has been done above; second, to find the same thrust at some horizontal section a little way above the base; third, to subtract the one thrust from the other, and call it the total thrust on the ring segment between the base and the horizontal section in question. When this has been determined, it is quite easy to determine the average stress on the ring segment in question by the method explained above.

Let us before consider the case of a truncated cone (Fig. 3) mounted on a

Fig. 3.



smooth plane, and loaded at first with its own weight only.

Let W = its weight.

w = the weight of the ring segment between the smooth plane, and any given horizontal section of the cone.

r^1 = the radius of the base ring.

r^2 = the radius of the top ring.

r = the radius at any horizontal section.

α = the angle of inclination of the slant side.

Let us first find the whole horizontal radial thrust outwards. To do this we must first know the centre of gravity of the figure. The perpendicular distance of the centre of gravity of the surface of a cone from its base is given by the formula $x = \frac{h}{3} \cdot \frac{r_1 + 2r_2}{r_1 + r_2}$ where h = the perpendicular height of the frustrum. Consequently the slant side is divided at the centre of gravity into two segments, which are respectively x. cosec. α and $(h-x)$ cosec. α.

Consequently the weight W may be replaced by its two components, namely, $W \cdot \frac{(h-x) \text{ cosec. } \alpha}{h \text{ cosec. } \alpha}$ acting downward all round the base ring, and $W \cdot \frac{x \text{ cosec. } \alpha}{h \text{ cosec. } \alpha}$ also acting downwards round the top ring.

Now the reaction of the plane is = W acting upwards round the base.

Hence the difference between this reaction and the weight = $W - W\frac{h-x}{h}$, and substituting for x its value given above, we have total force at base = W

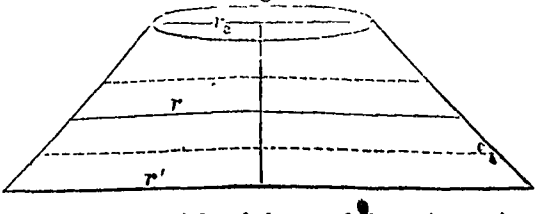
$$\left(1 - \frac{3(r_1 + r_2) - (r_1 + 2r_2)}{3(r_1 + r_2)}\right).$$

Now, the total horizontal radial thrust outwards equals this latter quantity multiplied by cotan. α.

$$= W\left(\frac{3(r_1 + r_2) - (r_1 + 2_2 r)}{3(r_1 + r^2)}\right) \text{cotan. } \alpha$$

Now let us find the value for this same thrust at a horizontal section of the cone situated a little way above the smooth plane, the radius of the ring of

Fig. 4.



the section being r. The weight of the part below the section being w, the weight of the segment above is of course $W - w$.

Now the weight of this segment above generates a reaction upwards at the horizontal section = $W - w$.

Also a certain portion of the weights both of the top and bottom segments may be considered as acting downwards at this section, the exact amount of each being dependent on the distances of the centres of gravity of the two portions from the horizontal plane which forms the section under consideration. Now the balance of these three forces, namely, the reaction upwards and the two weights downwards constitutes a resultant force which acts either up or down according as the reaction does or does not predominate over the two weights. So long as the resultant is upwards a tension is generated in the ring, and *vice versâ*, when the force tends downwards, the ring is in compression, but when the resultant is zero the ring is unstrained, and we are at the neutral point.

Let us now put these words into symbols.

The weight of the lower portion is w, and its centre of gravity is situated at a distance from the base

$$=\frac{(r^1-r)\tan.\ \alpha}{3}+\frac{r_1+2r}{r_1+r}.$$

Therefore the portion of w acting at the horizontal section,

$$w\frac{\frac{(r^1-r)\tan.\ \alpha}{3}.\frac{r_1+2r}{r_1+r}}{(r_1-r)\tan.\ \alpha}=w.\frac{r_1+2r}{3(r_1+r)}.$$

The weight of the upper portion is $W-w$, and the part of it which acts at the horizontal section may be found in the same manner to be

$$(W-w)\left(1-\frac{r+2r_2}{3(r+r_2)}\right).$$

Hence the algebraical sum of all three forces, viz., the reaction and the two weights may be found to be

$$(W-w)\frac{r+2r_2}{3(r+r_2)}-w\frac{r_1+2r}{3(r_1+r)}.$$

If we multiply this quantity by cot. α, we get the horizontal radial thrust at the section under consideration, and subtracting this from the thrust at the base of the cone found above, we get a quantity which represents the total thrust on the ring sement, between the horizontal section and the base. Calling this quantity T for the sake of brevity, we find the intensity of T per unit of circumference of the ring segment to be $=\frac{T}{2\pi r}$ where r = the average radius. Hence $\frac{T}{2\pi r}\times 2r=\frac{T}{\pi}$ is the thrust on a semicircle resolved at right angles to the diameter of that semicircle.

And as this thrust is resisted by metal in the ring, it is quite easy to find the average tension in the segment. If we want to find the position of the neutral axis, we must equate to zero the quantity expressing the resultant of the external forces at a horizontal section, and then solve this equation for r. Thus—

$$(W-w)\frac{r+2r_2}{3(r+r_2)}-w\frac{r_1+2r}{3(r_1+r)}=0$$

is the equation the solution of which for r gives us the radius of the neutral ring.

The above is the simplest possible case of the cone, but as it perfectly illustrates the general principles of the structure, and, as all other cases can be investigated in a precisely similar manner, it will be unnecessary to go into them further.

The original system of erection of the ironwork of the Rotunda proposed by Mr. Scott Russell has already been described, and an account in outline has also been given of the method actually adopted. This method, for which Mr. Harkort, the contractor, was responsible, was the design of his chief engineer, Mr. Steiger, and the whole plan will now be described in detail, not because it is a good or economical system, but simply because it is an original idea, the account of which naturally belongs to the history of the Exhibition. It should be mentioned here, that all the alterations in the ironwork entailed by this mode of erection were carried out partly by Mr. Steiger, and partly by the technical bureau of the Imperial Commission.

The railroad arrangements will first be described. A circular line was formed skirting the inner faces of the concrete foundations, and a radial one was also run from the centre to the circumference, and was eventually prolonged till it joined the branch railroad, which was constructed in the Prater expressly for the conveyance of Exhibition materials and goods. The points of intersection of this radial line with the two others were provided with turntables, so that wagons laden with iron could be turned on to either of the two service lines as occasion might require. The circumferential service line was of course employed for the conveyance of the materials destined for the columns and outer portions of the building, while the radial line served to transport the several parts of the two lanterns, with their roofs and platforms, to the centre of the circular area covered by the Rotunda. As fast as the wagons arrived their contents were unloaded along the sides of the branch line, and were allowed to remain there till wanted for erection. The material thus unloaded often lay for several months along the different sidings, and when required it was loaded again on to trucks made specially for the purpose, which were then shunted into the building. In order to facilitate this loading and unloading, a travelling crane was provided, mounted on an iron wagon; also a windlass was erected on timber framework over the branch line, near its junction with the service lines; underneath this framework the ordinary railway wagons could be run, and their contents transferred, at once if required, on to the specially made trucks; these latter were enormously strong, and were so constructed as to travel with ease on the rapid curve of the circular railway.

We now come to the actual erection, and begin as usual with the great columns. Round the outer faces of the concrete foundation blocks a circular scaffold was erected in the following way. Behind the site of each column four stout perpendicular timber posts were erected, and their heads connected by strong squared beams (see Plate XV.). As these posts had to support the screwing apparatus, and consequently, also the whole weight of the parts to be lifted, they were necessarily made extremely strong, and their footings very secure. To prevent them from overturning backwards, they were provided with stay posts also securely fastened. Between each of these set of posts, a light scaffolding was erected, the sole use of which was to support the platform on which the men worked. The squared beams connecting the heads of the posts formed the footings for strong cast-iron collars through which worked the screws employed in lifting the columns. Each screw was turned by a long lever (see Plate XVI., Fig. 11) provided with a ratchet apparatus, so constructed that it could work either forwards or backwards. To the lower end of the screw was attached a chain constructed like that of a suspension bridge, of long links of bar iron; there were three such links to every chain, the first and third being, of course, doubled. The joints were so arranged that the links could be easily detached from one another and from the screw. There were two screws and chains to each column, and the lowest pairs of links were attached one to either end of a lever, the central pin or fulcrum of which bore on a wrought-iron bracket fastened to the outer face of the column. The whole apparatus is shown in detail in the drawing (see Plate XVI., Figs. 13 to 22), in which A and C are the top and side views of the ratchet and lever. In B the top plate is taken off, thus exposing the working parts to view; *c c* is the ratchet wheel containing the hexagonal nut, *d*, in which the female screw is formed; *a a* are the two detents, one for raising and the other for lowering the screw; *b b* are eccentrics for putting either of the detents in or out of gear; *f f* are the springs which work the detents. H is the screw, G one of the links, and D and E the lever which bears on the wrought-iron bracket.

Before describing the actual process of lifting, we must revert for a moment to the columns. The foundation plates of these latter were first put in place. In order to bring them all to exactly the same level they were each mounted on four small wedges, and were then levelled by means of a theodolite and an ordinary levelling staff, the wedges being slackened or driven up till each plate was not only horizontal, but also at the same absolute height as its neighbours. The spaces left underneath the plates, between them and the concrete

blocks, were then filled up by grouting, and when the cement had set, they were all ready to receive the superstructure. The columns arrived each in five segments. The first of these to be put in place were the heads. They were brought into the area along the circular railroad, standing on their bases on the trucks, and in order to deposit each of them on its foundation plate, it was only necessary to bridge over the space between the trucks and the concrete blocks by means of slanting timber beams, and then to push the segments directly down the beams with ordinary screw-jacks. When they were all in place, they were connected to each other by means of the first gallery girders, and also by the lowest segment of the plating of the cone, and the innermost of the two coping rings; the outer one could not then and there be put in place because the uprights of the scaffolding left no room for it; its place was temporarily and imperfectly supplied by timber beams bolted to the lower edge of the cone. The lifting brackets were at the same time fastened to the outer faces of the column heads, the levers and links attached, and all was ready for the screwing to begin. It was of course necessary that the screws should be turned simultaneously, and in order to insure this, it was arranged that at the first beat on a bell the men should prepare, at the second they should push the levers forward, thus raising the screws, and at the third they should return to their original positions dragging the levers after them but leaving the screws, by means of the ratchet apparatus, in their raised position. This operation repeated a given number of times, the screws would of course be raised through their entire length, and the column head carried after them to exactly the same extent. As these latter advanced upwards, they were packed underneath with logs in order to guard against the effects of a breakdown. When the screws had been raised to their full extent, the whole operation was brought to a standstill and the chains were disengaged one by one from the brackets, and were each shortened by one link; the screws were then lowered again, and the shortened chains attached to the lifting levers, so that all was ready for a fresh start. When this second stage of the lifting was completed the chains were shortened by another link, the screws were again lowered, and the operation repeated just as before; when the last links of the chain had been removed, the lower ends of the screws themselves were attached directly to the lifting levers; and when this the fourth stage was completed, the first segments were raised high enough to admit of the second ones being thrust in underneath them. These were put in place in precisely the same manner as the others, the log packings having been first knocked away one by one. Each column head was then lowered by means of the screws on to the second segments, the junction plates were put in position, and rivetted, the lifting brackets unbolted, lowered, and fastened again, the chain restored to its full length, and, in fact, the whole apparatus was brought to its original condition, the only difference being that the columns were each now two segments long instead of one. All this was repeated till the whole of each column was in place; it must be mentioned, however, that as soon as the heads were raised clear above the scaffolding and screws, the second or outermost of the coping rings was rivetted in position, together with the bulkheads, &c., belonging to it.

It must not be supposed that all this went on smoothly, for in fact numerous accidents occurred which seriously delayed the progress of the work. It has been explained before that this system of erection threw heavy transverse strains on the columns during the process of lifting, the reason being that the centre of gravity of each did not lie in the same plane as the axes of the screws. The consequence was that, at the very first turn of the screws, the lower ends of the segments were bent outwards, so as to bite hard against the outermost angle irons of the foundation plates, thus tearing up these latter from their beds. Next it will be easily seen that the columns had a tendency to tumble inwards, revolving about the bearings of the lifting levers as centres, and compressing at the same time the rings which prevented them from falling; so great was the strain thus engendered, that till the outermost coping ring could be added, the roof plating was all crumpled up into wavy curves which had to be straightened by screw jacks placed in an inclined position on the ground, and which acted on the distant roofing through long poles. This

operation was very tedious and caused great delay. Another source of trouble was the constantly increasing deflection outwards of the lower ends of the columns as more and more segments were added, a condition of things which rendered it next to impossible to keep the lifting chains and screws truly vertical. This annoyance was eventually got rid of by tying the lower ends of the columns together by means of an iron ring (1,060 ft. in circumference), formed of flat bar iron, the individual bars being bolted together. Lastly, from beginning to end of the whole operation each pair of screws and chains manifested a tendency to twist together, for the cast iron collars in which they worked could not be spiked down sufficiently strong to keep them fast. The constant readjustment of these latter was the most tedious part of the whole work, but eventually all difficulties were overcome, and the columns and great ring were at last got in place. Then, however, it was discovered that the columns were not straight, and they had to be put right by means of screw jacks, pushing in here and thrusting out there, till at last all was got right with no worse consequences than that much time was lost and the whole building was a few inches out of its proper position.

At the same time that all this was going on, a colossal scaffold was in process of construction in the centre of the building, and on this were erected the platform of the great lantern, together with the uppermost segment of the cone and its accompanying rings, and also the ends of the radial girders. The general appearance and construction of this scaffold is shown in the engravings (see Plates VIII. and XVII.). There was no special difficulty involved in this portion of the work, all the individual parts having been raised by means of a small portable steam engine and windlass situated at the foot of the scaffold. The whole of this upper portion of the roof was mounted on wedges in order to admit of its being raised or lowered within certain limits.

The next operation was the mounting in one piece of each of the long radial girders, or rather of so much of them as lay between the inner ring of the coping ring, and the outer extremities of the top ends which were already in place. This was accomplished by means of cranes and windlasses worked by hand.

The girders were first brought in segments on to the ground, and then laid radially and rivetted together; where the ground was uneven they were laid on rough timber scaffolds formed of the logs which had previously been employed in underpacking the columns during their progress upwards. A stout plate of iron was then rivetted to the top flange at each end of the girder so as to stand vertically upwards. In each of these plates holes were formed in order to engage the lifting hooks, two of which, with as many sets of tackle, were provided at either end. This latter precaution was adopted in order to provide against the results of the possible breaking of one set of tackle, an accident which, had it happened, would have involved the destruction of the entire girder. The arrangement employed in lifting the small end consisted simply of a pair of stout beams laid horizontally so as to connect the heads of the two poles of the central scaffold, situated exactly over the final position to be occupied by the end of the girder in question. To these beams were attached the fixed pulleys, the ropes passing over which were wound up by windlasses on the ground. There were four of these latter, viz., one pair on each side of the girder. The ropes on either side being wound on to the drum of the larger of the two windlasses, was unwound on to the drum of the smaller one; by this arrangement the larger drum had never more than two or three turns of rope on it, and was thus enabled to exert its full power to the end of the lift.

The cranes for raising the heavy ends of the girders were quite different to those just described. They consisted each of a pair of trapezoidal frames of timber, standing on the top flanges of the coping ring, of the shape shown in the sketch (see Plate XVI., Fig. 12). These two frames were placed side by side at a little distance apart, and firmly braced together. The upper and longer side projected considerably, so as to overhang the column head. To the inner end of this top side were fastened the fixed pulleys, and to the outer end were attached a pair of stay ropes, the lower ends of which were secured to the foot of the column. The use of these stays was of course to prevent the frames

from tumbling inwards under the weight of the girder. The windlasses were arranged in a radial line behind each column, two being provided as before for each set of tackle. The shorter side of the trapezoid, viz., that which rested on the coping ring, was provided with a pair of hooks at its upper end, whose function was to prevent the whole frame from slipping off the rings. There was no other attachment of any sort, so that each frame could be freely pulled round the ring from one column head to another as fast as the respective radial girders were put in place.

The process of lifting was as follows :

The lighter end of the girder was first raised, the heavy end still resting on the ground till the whole had attained a slant slightly greater than the proper inclination of 30° 45.' Then the heavy end was lifted also, the upper portion continuing to move at the same rate, and this process was continued till the whole girder was raised somewhat above its final position. The heavy end was then gently lowered and drawn into its place over the column head by means of chains and differential pulley blocks attached to the coping ring, and when this was accomplished, the upper part was also lowered till it had assumed its right position, and was then bolted temporarily to the projecting topmost ends, which, it will be remembered, had been independently erected. The final rivetting was postponed till the whole ring platform had settled down into its proper place, for it had at first been pitched a few inches too high, in order to allow for the sinking of the central scaffold. In this way the 30 radial girders were successfully mounted; one solitary accident having occurred, which was caused by the top flange of one of them catching in a tree, and getting twisted over and crumpled and torn like a sheet of brown paper. It had consequently to be lowered and repaired. When in place, the girders were found to sway very considerably with the wind, and had therefore to be stiffened provisionally by timber beams, which were arranged so as to supply the place of the ring girders, pending the erection of these latter and the skin of the cone.

The next step was the building up of this skin. It was accomplished by means of a very ingenious system of hanging scaffolds, which were suspended from the top flanges of the radial girders. They were constructed in the following manner :—Two frames, each resembling an inverted figure 4, were provided for every girder, *i. e.*, one frame on each side of the girder. The top ends of the vertical beams in each frame projected considerably abovet he upper flange, as shown in the sketch in the next column, and their heads were connected together by a strong horizontal cross piece, which also projected on either side beyond the vertical beams. To the projecting ends of this horizontal piece were attached the pulleys used in lifting the plates of the cone. Resting on the top of the girder underneath the cross piece was a broad cast-iron roller, which was connected by means of a wrought-iron axle with the vertical beams. The use of this roller was to enable the hanging scaffolds to travel upwards as fast as the lower portions of the cone were completed. The upward motion was communicated by means of ropes connected with the scaffolds, and wound round windlasses placed on the great lantern platform. The two frames forming one hanging scaffold were, of course, firmly braced together, and the 30 scaffolds were connected one with another by means of stout joists laid loosely on the horizontal part of the inverted figure 4 (see Plate XVIII., Fig. 13).

In this way the supports were obtained for a circular platform which was used to carry the workmen and their "material." The platform, of course, moved up the cone with the hanging scaffolds, the only precaution necessary being to saw off the ends of the joists as the scaffolds approached more and more towards the centre. It was, of course, also necessary to steady the whole by means of ropes passing from the lower ends of the frames over pulleys fixed in the first gallery, and thence down to the ground where they were made fast. Had this precaution been neglected, the whole combination of frames and platform would have swung round the pulleys as centres, till the centre of gravity of the system lay vertically below the axis of the roller. The manner of mounting the plates was as follows:—They were hoisted one by one by means of windlasses on the ground, and ropes passing over the

pulleys mentioned above, as attached to the horizontal cross piece of the hanging scaffold. It will be remembered that the plates are arranged on the roof so as to break joint, and when a tier of them had been mounted their upper or projecting ends were prevented from drooping by attaching them to a beam laid horizontally between every pair of radial girders. When the plating had advanced as far as the site of a ring girder, this latter was put in place, not all in one piece, but in individual plates, which were mounted in the same way as the roof plates.

Thus the cone was gradually built upwards from the bottom, but, at the same time, it was being completed downwards from the top. This part of the operation was executed without the help of hanging scaffolds as follows: The last ring girders but two was first made up in segments on the ground and then hoisted into its place and made fast to the radial girders; a platform was then formed, the supports of which rested at one end on the great central scaffolding, and at the other on the lower flanges of the radial girders. This platform formed a base of operations for putting up the higher portions of the lower cone. The lower part, when it had advanced far enough, was joined on to this latter, the different scaffolds and platforms removed, and the roof was thus far completed.

While all this work had been going on the two lanterns, with their roofs, had not been neglected, but had on the contrary been proceeded with quite independently. Owing, however, to their comparatively small size there was nothing at all difficult or out of the way in their erection. The columns were each hoisted in one piece by means of the portable steam engine at the base of the scaffold, and when landed on the great platform they were put in place by means of a tall tripod and a windlass. As fast as they were erected they were bound together by the double coping ring at their heads. The platform of the little lantern was completed at the same time, and then the light radial girders connecting it with the column tops were easily mounted and put in place. In order to put on the roof plating a platform was formed supported by beams stretched from the neighbourhood of the column heads to the central scaffold, and when the work got out of reach a second lighter platform was built on the first one, of trestles and boarding. In this way the second cone was completed, and the top lantern with its domed roof was erected in an equally simple fashion, but as there was nothing in this part of the work which is not carried out in engineering structures every day, it is not necessary to speak of it in greater detail.

An accurate account has now been given both of the proposed method of erection and of the system as actually carried out, so that every engineer can judge for himself of their comparative merits. There will probably be but one opinion on the subject. The former plan required for its execution only a very insignificant plant, whereas in the latter two gigantic scaffolds and numerous smaller ones, 64 special tools in the shape of the lifting tackle for the columns, 100 windlasses, two steam engines, and ropes, not measured by yards but by leagues, had to be put in requisition. Moreover, the influence on the weight of the entire structure will not be forgotten; but notwithstanding all these means, which for the time being quite obscured the end, the work was at last neither executed accurately nor finished in time.

We have thus completed the account of the Industry Palace and its special feature, the great Rotunda; and we may refer the reader in conclusion to the various sketches contained on Plates XVII., XIX., and XX., which serve to give an idea of the appearance of the Industry Palace and Rotunda during their progress towards completion.

The Machinery Hall, intended for the exhibition of machinery, which is retained as a permanent building, is probably the largest of its kind in existence, being no less than 797·14 metres (2,615 ft.) long by about 50 metres (164 ft.) wide, that is to say, covering an area of 40,009 square metres, or about 47,800 square yards. It consists of a central nave flanked by an aisle on either side, all three divisions running continuously the whole length of the building. The nave, which contains the shafting and stationary engines for putting the machinery in motion, is 91 ft. 10½ in. in width, and 43 ft. 4 in. in height to the springing of the roof, while the aisles, which serve for the

exhibition of hand tools and small machinery not in motion, are each 28 ft. in width and 16 ft. 11 in. in height. The body of the building is formed of four long rows of brick piers, so arranged that each pair in the nave constitute the supports for one of the iron trusses of the roof which cover this division, and similarly each column of the two outside rows carries one end of the straight iron rafters which support the simple lean-to roofs of the aisles. The other ends of these rafters are attached to the piers of the nave. Each of these piers is founded on a concrete footing, those of the nave being each 4 ft. $2\frac{3}{8}$ in. by 5 ft. $2\frac{3}{10}$ in. in cross section, while the corresponding dimensions of those in the two outside rows are 4 ft. $2\frac{3}{8}$ in. by 2 ft. 7 in. Considering that none of these piers had any shafting to carry, and that the work done in the Machinery Hall was of a kind to engender serious vibrations, it must be allowed by everybody that the dimensions given above are very much in excess of what they need be.

At the point where the roofs of the aisles meet the piers of the nave, these latter are connected together by solid brickwork arches, the rectangular spaces above which are filled with windows; the lighting of the aisles is accomplished by means of windows placed between every pair of piers of the outside rows.

The roof of the nave consists of a series of iron trusses, the span of each of which is 97 ft. $0\frac{9}{10}$ in., and the depth from the head to the foot of the rafter 22 ft. $8\frac{3}{4}$ in. The rafters are rolled I-beams, the struts are of cast iron, while all the rods in tension are, as usual, round wrought-iron bars. These trusses are connected together by wooden purlins, which are covered by diagonally laid planking, the whole being then plated with zinc. The wood and zinc-work of the aisles is executed in a similar manner, but the rafters are simple wrought-iron girders (see Plates XX. and XXIII.).

The flooring is formed by filling up to the required level with gravel, in which joists, otherwise unsupported, are bedded; these joists carry the flooring boards, which in the nave are 2·6 in thick, and in the aisles 1·4 in.

The shafting in this Exhibition was rather exceptionally arranged. There were two lines of main shafting carried by as many rows of cast-iron columns erected parallel to the axis of the building, each row being 9 ft. $10\frac{1}{10}$ in. distant from that axis; the columns were consequently 19 ft. $8\frac{3}{10}$ in. apart transversely, while longitudially they were set at distances of 11 ft. $9\frac{1}{3}$ in. Their heads in each row are connected together by massive plate girders, while transversely also every column is connected to the corresponding one of the opposite row (see Plate XVIII., Figs. 2, 3). As a rule, each column was a cast-iron tube $9\frac{7}{10}$ in. diameter in the shaft, and swelling out at the base; but wherever a stationary engine was situated, the arrangement was slightly different, for here, for the sake of greater security, four ordinary columns were grouped together and bolted into one. The shafting was 3·6 in. in diameter, and was carried on American adjustable bearings which can be raised or lowered vertically through a considerable distance by means of screws working in lugs which were cast on to the tubular columns (see Plate XVIII., Figs. 4 to 9). This system is undoubtedly very useful in quickly built workshops where the footings may be insecure, and the columns for carrying the shafting mere timber posts, which at the same time support the roof of the shed, but was hardly necessary for a building like the Machinery Hall of the Vienna Exhibition, where the foundations are so sure, and the columns so numerous, and of such a character as to render it impossible for the shafting to get out of the true line. On Plate XXI. are shown the details of the columns, shafting, &c., erected in the Machinery Hall.

It may be mentioned in passing, that cold rolled shafting was used in the United States' section, and that in the English section Messrs. A. Ransome & Co. adopted their method of underground shafting.

The boilers were all located outside the main building in separate sheds, each country exhibiting machinery in motion having had its own boiler house. These consisted merely of rectangular pits sunk in the earth to such a depth, that the tops of the boilers came up to about the level of the ground; the pits were of course bricked in, and access gained to them by a flight of steps on either side, so that the public could view their contents as objects of

exhibition; they were, moreover, surrounded by brick parapets, and were covered over by plain shed roofs supported on open timber framing.

Each house had its own chimney, consisting of a long tube of wrought-iron plate, standing on a brick pedestal, and stayed with chains.

The great agricultural sheds were two in number, one between the western ends of the Machinery Hall and Industry Palace, the other at the eastern end of the Machinery Hall. There was also added a small separate shed at the back of the larger western one, exclusively for American exhibits. These buildings having been intended solely for agricultural products, and machinery not in motion, were made altogether of woodwork, and that too of the roughest sort. Like the Industry Palace, all three sheds were founded on piles, on which the skeleton buildings of timber frames were erected, both walls and roofs were then boarded over, the walls with overlapping boards so as to be weather-proof, while the roofs were made water-tight by means of ordinary roofing felt. The flooring, like that of the Industry Palace, was formed of boards supported by joists, which are carried on the heads of the piles.

The western shed consisted of a main rectangular building, with four wings branching out of it on one side; the outer ends of these wings were connected together by a covered gallery, and thus three courts were obtained which were available as exhibition space. The American building was merely a simple oblong shed, while the large eastern hall consisted of an oblong building connected by means of covered passages with another shed similar in general arrangement to the western one just described. It had, however, only three wings, and two courts. There was nothing in these buildings viewed either from the artistic or engineering point of view, which deserves imitation, or merits a more detailed description.

The Vienna Exhibition was unfortunately finished before the completion of the water-works, which now supply the town with water at a high pressure. But such a vast organisation as this Exhibition could not exist a day without a regulated water supply of some sort, and hence it became necessary to erect special works in order to make good the deficiency.

The arrangement, as carried out, was the design of Professor Grimburg, and had for its object the supply of the fountains, hydrants, and fire-engine reservoirs, the feedings of the boilers and the kitchens of the different restaurants, and also the sluicing of the waterclosets and other sanitary conveniences. The plan was as follows:—For the supply of the high-pressure water necessary for the fountains, hydrants, and water-closets, a water tower, 143 feet high, was erected near the western end of the Machinery Hall. This tower, which was a very creditable piece of work, is fully illustrated in Plate XXII. of the Atlas (see Plates XXII., XXIII.). The design for the structure was prepared in the drawing office of the Exhibition Commissioners, under the superintendence of Professor Ritter von Grimburg, and the work was successfully executed by the Erste Brünner Maschinenfabriks Gesellschaft, the makers of the pumping engine by which the water was raised into the tank at the summit.

The tower was situated about 200 ft. from the engines, and it consists of a stone pediment 15 ft. 6 in. in height, on which was erected the skeleton iron structure. The latter consisted of eight stories, six of these being each 16 ft. 8 in., while the upper and lower stories were, as will be seen on reference to fig. 1, very much shorter.

As will be seen from figs. 1 and 2, the iron structure was composed of eight cast-iron columns, disposed at the corners of an octagon, these columns, which were 16 in. in diameter and 1 in. thick, being made in lengths connected by flanges (see figs. 3 and 6), and being firmly braced together at seven points in their height. The bracing consisted of rolled iron girders or struts of channel section, disposed so as to form an octagonal frame connecting the columns horizontally, while similar struts, but of lighter section, were disposed as diagonals. Fig. 1 shows the general arrangement of this bracing, while figs. 4 and 5 show the mode of connecting the bracing to the bases of the columns; fig. 8 is a section of one column just above the lugs or wings to which the bracing is secured; and fig. 14 shows the mode of connecting the horizontal and diagonal struts to the wings, which we have just mentioned as

being cast on the columns. Besides the struts of which we have been speaking, the columns were also braced by radial ties connecting them with the rising main, which passed up the centre of the tower; the construction and mode of connexion of these ties are shown by figs. 12 and 13.

The upper story consisted of columns of a height of 7 ft. 3½ in., these columns being of the form shown by figs. 9 and 10, and having attached to them wrought-iron brackets carrying a platform or gallery, 4 ft. wide, which surrounded the tank. The construction of this gallery, and the mode of supporting it, will be clearly understood on reference to figs. 9 and 10, the former of these figures also showing the manner in which this tank itself was supported by a curb or ring girder of cast iron. The gallery was provided with a neat handrail, as shown in fig. 1. This gallery commanded an admirable view of the Exhibition buildings, and access to it was gained by a conveniently arranged staircase, the constructive details of which are shown by figs. 7, 8, and 11.

The reservoir or tank at the top of the tower was constructed of wrought-iron plates; it was 25 ft. in diameter and 19 ft. in height, so that it was capable of containing about 9,000 cubic feet. The water was delivered into the reservoir through a central rising main, to which we have already referred, while it was drawn off through two of the columns of the tower, these columns being each connected to the water main by a branch, arranged as shown in fig. 3. The pumps were capable of delivering into the reservoir 16,000 cubic feet per hour, while the head given by the height of the reservoir was sufficient to enable a powerful jet of water to be delivered upon the roofs of all the Exhibition buildings, except, of course, the higher parts of the Rotunda. An electric water gauge is fixed on the reservoir, and, connected to the engine house, conveyed to the engine driver information respecting the height of water in the tank.

The tower was successfully erected without the employment of any special scaffolding and without accident, and the structure was altogether a very creditable one to all concerned in its design and erection. The total weight thrown upon the base due to the iron structure and the water in the reservoir was about 450 tons.

This water-tower, which, as we said, was situated close to the western entrance to the Exhibition, furnished about 18,000 cubic feet of water per hour, and supplied the fountains, nine in number, as well as 180 hydrants. It drew its supply from a well 18 ft. wide, and 22 ft. deep, by means of a horizontal steam engine of 100 horse power nominal.

Two of the larger fountains were fed by a separate apparatus, which served also as a reserve to the water-tower just described. The arrangement was rather peculiar, for there was no reservoir, the pumps forcing the water directly into the pipes which lead to the fountains. The plan is an American one, and everything about it was original; the two engines, which were each of 50 horse power, worked the pumps by direct action, without the intervention of cranks. The well from which the water was drawn was in this case 12 ft. wide, by 20 ft. deep, and had to furnish 6,000 cubic feet per hour.

The boilers and condensers of the Machinery Hall were supplied by another set of pumps, which were quite different from the two sets already mentioned. The system in this case was a sort of Norton's tube well on a large scale. Continuous iron piping was driven into the ground till water was reached, and then the pumps were attached to the heads of the pipes; thus no well was needed, and the water was sucked up through the pipes, and delivered into a reservoir, which in this case was situated 18 ft. above the level of the floor of the Machinery Hall. It will convey an idea of the requirements of a large exhibition in the matter of water when it is stated that the united length of the pipes connected with the water-works in the Prater was about 12 miles.

One of the most important of the many arrangements which received the attention of His Excellency Baron Schwarz-Senborn, the General Director of the Exhibition, for the accommodation of its host of visitors, and for its preservation from insanitary influences, was the establishment of a number of

retiring-rooms in the Industrial Palace, and in the open grounds, and also of a system of drains for removing the sewage therefrom, as well as from the restaurations, pavilions, and other buildings—the well-arranged and abundant water supply laid down at all parts affording facility for the perfect working of the fittings and drains. Early, therefore, in 1872, His Excellency contracted with Mr. George Jennings for providing and fixing his patent water-closets, lavatories, and urinals in the several retiring-rooms, and for laying the system of drains; Mr. John Phillips was despatched to Vienna, as engineer, to arrange and execute the works, under the direction of Professor Ritter von Grimburg, the chief of the mechanical engineering section of the Exhibition.

It was intended at first to use the New Danube Regulation Canal at the back of the Exhibition for the drainage outlet. But, owing to the absence of a stream therein at the time, the work being then incomplete, it was deemed prudent not to do so, but to use the Danube Canal instead. This is a swift stream, a branch of the Danube itself, running eastward at the boundary of the Prater, three-quarters of a mile from the south front of the Exhibition. When the locations of the several buildings and retiring-rooms, and the exact position of the drainage outlet were determined, plans and sections of the system of drains, showing their courses, inclinations, depths, and sizes, were prepared by Mr. Phillips, and, these being approved by Professor Grimburg, the works in accordance therewith were commenced.

By reference to a record of the levels of the Danube Canal for a number of years, it appeared that it was subject to a rise and fall of about 12 ft., its highest level having been nearly 9 ft. 6 in. above, and its lowest 2 ft. 6 in. below, the city datum. It also appeared that the Palace floor was 16 ft. 6 in., and the ground along its front and back 12 ft. above this datum. Consequently the floor was 7 ft., and the ground only 2 ft. 6 in., above the highest flood level in the canal. From this it was evident that, to lay the drains at sufficient depth to carry off the sewage from the retiring-rooms, pavilions, restaurations, and other buildings, and with sufficient fall for it to flow without depositing, they would be subject to long periods of flooding, and that, as no head or pressure of water could be gained to produce an outward current, so as to force the sewage through the water lying in the drains, they would soon choke up.

In order, therefore, to give the drains ample depth and fall, to prevent them from being flooded, and to produce a constant flow of the sewage along them, and a discharge of it at the outlet, it was determined, after mature consideration, to place the main drain at the outlet one fourth of the rise of the stream above its lowest level, namely, 6 in. above the city datum, or 9 ft. below the highest flood level, and 11 ft. 6 in. below the ground in front of the Palace, to fix a valve on the outlet, and to pump up the sewage when the stream in the canal was above the outlet.

The arrangement by which this plan was carried out was as follows:—At a short distance back from the canal, and in the line of the main drain, two 10-ft. cylinder reservoirs of wood staves, 20 ft. in length, were sunk 6 ft. below the level of the main drain, one for receiving, and the other for discharging the sewage. A 15-in. pipe was fixed between them, opposite to, and level with, the drain, with a valve hung on its outlet end in the discharging reservoir, and a 15-in pipe was laid from this reservoir into the canal, with its outlet carried 2 ft. under the lowest water level therein. When, therefore, the stream in the canal was above the main drain emptying into the receiving reservoir, its pressure closed the valve in the discharging reservoir, and, by means of a 10-horse power steam engine and a 6-in. centrifugal pump, the sewage was lifted from the former into the latter, whence it flowed by its own gravity through the pipe into the canal; and when the stream therein was below the drain in the receiving reservoir, the valve was opened, and the sewage passed direct through both reservoirs into the canal.

In determining the sizes of the main drains, two material points presented themselves for consideration. The first was to reduce the cost of the drains, and also that of pumping up the sewage, as much as possible. The second was to give the drains such gradients and sizes that, while the sewage streams

should have sufficient velocity to prevent the matters in suspension from depositing, they should fill the drains, and so prevent the sewage itself from emitting offensive gases. The first was accomplished by excluding from them the rainfall from the roofs and surface, the water in the subsoil, and the waste and condensing water from the steam and other engines in the Machinery Hall, the whole of which water, if it had been admitted into them, would have increased their capacities threefold, and correspondingly increased their cost, as well as that of pumping. The second was accomplished by giving the drains such gradients that the sewage was discharged with a velocity of about 80 ft. per minute, that velocity having been found by the engineer to produce sufficient energy in highly diluted sewage from closets to prevent it from depositing, and providing such capacities that they were nearly always running full.

With regard to the water from the roofs, surfaces, and engines, which was comparatively clean, separate provision was made for discharging it by small pipe drains, which were laid from the rain pipes, the gullies, and the engines, into dry brick wells sunk through the subsoil into a stratum beneath, which, as it consisted of large shingle and small boulders, readily received and dispersed it. This stratum was, moreover, in free communication with the beds of the Danube and Danube Canal, and therefore was always charged with water from these streams; in fact, it formed an underground lake, which was practically inexhaustible. It was from this source that the water was obtained for the steam and other engines in the Machinery Hall and elsewhere; for charging the fire-mains; for the fountains; for watering the roads, avenues, walks, floors, lawns, and plants; for the offices, restaurations, and pavilions; for the retiring rooms; and for flushing the drains.

Before describing the drains as laid down, it may be observed that owing to the extremely loose nature of the subsoil, which consisted of sand, gravel, and beds of small shingle, like peas and beans, it was necessary to use great precautions in excavating and strutting the trenches for the drains, so as to prevent the sides from falling in and burying the workmen. Hence, in order to avoid this the engineer was compelled to send to England for a number of men skilled in this kind of work, whom he distributed among the native workpeople. These latter consisted of Austrian, Hungarian, Bohemian, Sclavonian, and Italian men and women, who were employed for more than six months—the men in digging and aiding to strut the trenches, and lay the pipes, and the women in filling in and ramming the ground as the pipes were laid. The following was the system of drains as laid down.

From the pumping station near the Danube Canal a main 15-in. drain was laid northward across the Prater, and along the Central or Kaiser Allee, to near the south front of the Palace for a length of about 4,000 ft., and with a fall of 1 in 1,000. Into this drain a 6-in. drain was laid from the retiring rooms, near the Post-Office, the length being 600 ft., and the fall 1 in 300.

At the upper end of the 15-in. drain a curved double junction was formed of brickwork in Portland cement. From this junction two 12-in. drains were laid, one eastward and the other westward, along the Elizabeth Avenue, parallel with the Palace, the length of each drain being 1,250 ft., and the fall 1 in 800. Into these drains 6-in. drains were laid from the Kaiser Pavilion, the Jury Pavilion, the two retiring rooms in the Palace east and west of the chief central entrance, the two retiring rooms in front of the Palace towards its east and west ends, and the Russian, French, Italian, Swiss, and Liesinger restaurations.

At the upper ends of the 12-in drains curved junctions were also formed of brickwork in cement. From the eastern junction a 9-inch drain was continued in that direction for a length of 650 ft. and with a fall 1 in 400. Into this drain 6-in. drains were laid from the Police Station, the Egyptian, Turkish, and Persian pavilions, and the Turkish restauration and coffee divans near the south-east end of the Palace. Also from the western junction a 9-in drain was laid in that direction for a length of 400 ft., and with a fall of 1 in 400. Into this drain 6-in drains were laid from the Hungarian, the Pilsner Actien, the Pilsen Bürgerlich and the American restaurations, near the south-west end of the Palace.

The foregoing drains completed the sewage drainage of the several buildings along the south front of the Palace. It would be impossible for drains to be subject to a greater ordeal to keep them free from deposit and clear than these were, especially the western 12-in. and 9-in. branch, and its 6-in. tributaries. At the Liesinger, the Hungarian, the Pilsner Actien, and the Pilsen Bürgerlich restaurations tens of thousands of persons dined daily from the opening to the closing of the Exhibition. Sometimes as many as 10,000 persons dined, and 22,500 seidel glasses of beer were drunk per day at the Pilsner Actien alone; and proportionate numbers of persons dined, and glasses of beer were drunk at the other restaurations named, except the Hungarian, where the staple drink was wine from Hungary. Hence the quantity of sewage that came from these places, particularly washings, refuse, and fat from the kitchens, was enormous. In the drains from the kitchens special traps were provided by the engineer for intercepting the refuse and fat. But so great and continuous was the cry from the crowds of diners for "Kellner, Speisen, and Bier," that no one had time to attend to them, or, indeed, to anything but the demands on the kitchen and the beer-barrel. Now and again one or the other of the tributary drains would stop up, and then came a dead-lock at the closets and the sinks, and a request from the restauration proprietor for the immediate attendance of the "Ober Ingenieur." Upon opening the drains they were invariably found to be stopped by a pair of trousers, a pair of stockings, and a newspaper, some table napkins, some dish-cloths, and brushes, some large pieces of meat and bones, or some broken beer-glasses, which had been forced through the closets and sinks; and bushels of fat were taken out of the drains, as well as out of the reservoirs at the outlet.

From the junctions at the upper end of the 12-in. drains, already mentioned, two 9-in. drains were continued northward across the Palace, one to its north-east end, and the other to its north-west end, the length of each being about 1,100 ft., and the fall 1 in 600; and into these drains 6-in. drains were laid from the retiring rooms in the Palace at those places. From the 9-in. drain, at the north-west end, the same sized drain was continued thence northward past the west end of the Machinery Hall, and along the back thereof for a length of 1,300 ft., and with a fall of 1 in 500. Into this drain 6-in. drains were laid from the British Commissioners' Pavilion, the Police Station, the Vienna bakery, the English restauration, the retiring rooms at the east-end of the British Agricultural Hall, the three retiring rooms at the back of the west half of the Machinery Hall, the British Workmen's Houses and Laundry, and the Vienna Buffet. Also from the 9-in. drain at the north-east end of the Palace the same sized drain was continued westward along the back of the Palace for a length of 600 ft., and with a gradient of 1 in 600. Into this drain 6-in. drains were laid from the Police Station, the Silberegg Restauration, and the retiring rooms at the back of the Schwarzenberg Pavilion,

The foregoing were the whole of the drains which discharged the sewage produced in the Exhibition into the Danube Canal. Their sizes and lengths were as follows:—15-in., 4,000 ft.; 12-in., 2,500ft.; 9-in., 5,500 ft.; 6-in., 5-in., and 4-in. together, 13,000 ft.; making a total length of 25,000 ft.

Brick shafts, 2 ft. 6 in. square, and from 100 to 200 yards apart, were carried up from the main drains, at the junctions and other convenient places, to the surface, for examining, ventilating, and flushing them. The ventilation was effected through perforations in the shaft covers at the surface. No other provision was found to be necessary, for, owing to the almost perfect clearance of the drains daily by the copious and continuous flow from the retiring rooms, the restaurations and other buildings, which nearly and sometimes entirely filled them, deposit and decomposition were avoided, little or no effluvium was engendered, and consequently no smell was ever perceptible from them. Occasionally strong flushes of water were sent through them from hose put down the shafts from hydrants near at hand on the water mains. The total length of the main drain and the western branch was 7,650 ft., and the total fall 10 ft. Floating substances, which were discharged down the closets at the head of this drain, passed through into the reservoir at the outlet in one hour and 36 minutes, equal to a velocity of 80 ft. per minute nearly.

Before dismissing this part of the subject, it may be remarked that, owing to the extremely flat gradients that could be given to the main drains, it was necessary, for their efficient working, that the pipes should be laid accurately to the gradients, and that the joints should be made perfectly water-tight. With the short, or 2-ft. stoneware drain pipes, and the much larger space in the socket ends than the size of the butt ends, as now manufactured, strict conformity to the requirements referred to was most difficult to attain. This gave the engineer great anxiety and trouble, as the success of the work mainly depended upon it. He therefore, from a spirit level on the surface, put in the exact gradient of each drain at every 10 ft. or 12 ft., and had, as far as was practicable, the joint of each pipe filled full all round with Portland cement, and pointed, and the inside frill of cement removed and drawn out as each pipe was laid. By this means an unchecked flow of the sewage streams was insured and maintained, and very little of the liquid was lost by leakage.

Engineers experienced in sewerage works know that, as the 2-ft. stoneware pipes, as usually made, necessarily produce a multiplicity of joints, and the large and irregular space in the sockets cause a drop at the bottom and top of the joints, checking the flow of the stream, reducing the bore of the drain, and preventing the joints from being made water-tight without a deal of trouble, no drain can be laid so even and uniformly cylindrical, and so water-tight at the joints as it should be. What really is required is that the pipes should be in lengths of 3 ft. and 4 ft. (they are so made in Germany and Austria), which would reduce the number of joints one-third and one-half, and that the socket and butt ends should be formed so that when they are put together a part, all round, should fit as accurately as a ground stopper in a bottle. The bore of the drain would then be regular and concentric, and the joints air and water-tight. In Belgium a stout india-rubber ring is slipped into a slightly fluted groove formed near the butt end of each pipe. When the pipes are laid the projecting rings press tightly against the sockets, sealing the joints and insuring the concentricity of the drain.

It may also be remarked that, had the main drains been made much larger than they were, or large enough to discharge the rainfall and engine water as well as the sewage, the gradients and quantity of sewage remaining the same, the streams would have been so spread, lowered, and weakened, and so exposed to the action of air in the drains, that doubtless deposit would have ensued, and offensive gases emitted. And then, to absorb or carry off the gases, trays of charcoal must have been placed in the shafts, or ventilating pipes continued upwards from them into a higher stratum of the atmosphere. It was demonstrated in the case of this drainage, as it often has been in similiar cases, that the nearer the capacities of sewers are made to the quantities of sewage to be discharged by them, taking care to give the streams, by the inclinations and contracted form of the sewers, sufficient velocity to prevent deposit, the less will be the emanation of gases from the sewage, the freer will be the sewers from such gases, the less will they act as retorts to convey, by the house drains, typhoid or other zymotic disease germs amidst the living, and the sweeter will be the air within and surrounding the houses in connexion with them.

There were 24 sets of retiring rooms, 12 for ladies and 12 for gentlemen. Six were in the Palace, two in the building near the Post-Office, and 18 in specially constructed pavilions in the open grounds. Each set of rooms for ladies consisted of a reception, a lavatory, and a closet-room; and each set of gentlemen's of a reception, a urinal, a lavatory, and a closet-room. The rooms were approached in the order named; and were large, lofty, well lighted, and well ventilated at both ends.

The lavatory basins were "Jennings's patent tip-up," fixed mostly in pairs, and some in threes in a semicircle, with polished marble and enamelled slate tops and back skirtings carried on ornamental wood-cased stands. In each ladies' lavatory-room in the Palace there were four pairs of these basins; and in each gentlemen's room three pairs and a range of five. There was also a separate tip-up pillar lavatory in these rooms. In each ladies', as well as gentlemen's, lavatory-room in the open grounds there were two pairs, vis-à-vis.

The waterclosets were "Jennings's patent closets," provided with polished mahogany seats. There were ranges of ten and six of these, vis-à-vis, in each ladies' closet-room in the Palace; and ranges of six and two, vis-à-vis, in each gentlemen's room. There was also a range of seven in each ladies' closet-room in the open grounds, and a range of four in each gentlemen's room. Fluted matched boarded partitions, 7 ft. high, divided the closets from each other.

The urinals were "Jennings's patent three-person and six-person," with central basin of galvanised iron, partitions of enamelled slate, and iron foot gratings. Four three-person were fixed in each of the three urinal-rooms in the Palace, and two "three-person" and one six-person" in each of the nine urinal-rooms in the open grounds.

In the Kaiser Pavilion there were four separate closets, three being of superior quality, and three tip-up pillar lavatories; and in the Jury Pavilion a range of three closets, two tip-up pillar lavatories, and six white flat-back urinals. The British Commissioners' Pavilion was provided with two separate closets and three lavatories, one closet and one lavatory being specially fitted up in connexion with the Prince of Wales's apartments. In the Khedive of Egypt's Pavilion there were three closets, one of which, of special construction, was attached to the Khedive's suite of rooms. These closets, with *seats*, were quite a novelty to the Egyptians. They do not *sit*, but *stand* on a broad stone step raised 4 in. above the floor, with a hole 14 in. in diameter near the back of the step, and a narrow slit, 4 in. wide, coming from the hole towards the front. In the several restaurations, before mentioned, there were ranges of closets for ladies, and ranges of closets and urinals for gentlemen. At the back of the Machinery Hall two sets of free latrines were provided for the male and female workpeople engaged in the Machinery Hall and in the open grounds; and 14 "six-person" urinals were distributed about the grounds for the accommodation of the visitors.

Under the floors of the retiring rooms in the Palace, and in the open grounds, drains were laid from the lavatories, closets, and urinals into general syphon-traps formed just outside the buildings; from the traps 6-in. drains conveyed the sewage into the main drains; and from over the outlets of the traps pipes were carried above the tops of the buildings for ventilating the drains between the traps and the main drains. The workpeople's latrines were also drained into the main drains, as were several of the "six-person" urinals in the grounds.

To all the lavatories, closets, and urinals in each set of retiring rooms, there was an ample supply of water. This was taken to the fittings by branch pipes from a horizontal pipe laid behind the ranges of closets, and carried up the angles of the room to two small cisterns placed apart in the roof, the cisterns being supplied from the main by a pipe and ball-cocks in the usual way. By this arrangement the pressure from the main, which was equal to four atmospheres, was broken, and a moderated pressure, and an equalised supply, were obtained at all the lavatories, closets, and urinals. As the supply in the main was constant, immediately there was a draught at a lavatory or a closet, the water in the cisterns sank, the ball-cocks opened, and the same quantity that was drawn off flowed into the cisterns. Even when there was a simultaneous draught at two or three lavatories or closets, the quantity and pressure in the pipes descending from the cisterns always gave the required supply and flush in the lavatory and closet basins. Water was also supplied, on the same principle, to the closets, urinals, and lavatories in the restaurations and pavilions, and it was laid on to the workpeople's latrines and the urinals in the grounds.

The total number of lavatories fixed in the retiring rooms, pavilions, and restaurations was 500, of closets 260, and of urinals 240. When the whole of the drains and sanitary fittings were completed, they were thoroughly tested, and found to perform their functions most satisfactorily; and they continued so to act during the course of the Exhibition, under the management of Mr. Phillips, as engineer for the General Direction, who has been presented with a special testimonial by His Excellency Baron Schwarz-Senborn, "for the "distinguished services he had rendered in arranging and successfully exe- "cuting the works." Professor Grimburg and his staff of engineers also

rendered most earnest and able assistance in carrying out this important work.

The retiring rooms were conceded during the Exhibition to Mr. Paüsens, of Vienna, whose charges were, in the Palace, for a lavatory or a closet 20 kreutzers, equal to 4½*d.*; and for a urinal 10 kreutzers, equal to 2¼*d.*; and in the rooms in the open grounds half the above. There were two female attendants in each set of rooms—one to take the money and issue tickets, the other to receive the tickets, wait on the visitors, and keep the fittings in order.

Want of space prevents us from referring to the numerous buildings for various purposes which covered the area enclosed by the Exhibition boundaries. There were more than 150 of various sizes and forms of construction. We may, however, call special notice to the elaborate pavilions of carved timber, contributed by Russia, Switzerland, and Sweden, and to those of a totally different character, the iron buildings by Messrs. Hemming & Co., the chief of which formed the pavilion for the Prince of Wales, and at the same time, the bureau of the British Commissioners. The other consisted of houses sent out by the same manufacturers for the accommodation of the British workmen employed by the Commission. The general arrangement of these houses, each of which contained accommodation for 28 men, is shown in Plate XXIII. of the Atlas. A totally new feature however, and one which especially struck the visitor, were the pavilions erected by Turkey and Egypt, both of which countries made great efforts to be worthily represented at Vienna, and spared no expense to illustrate in the most practical manner possible the peculiarities of their respective countries in industry, art, commerce, and social life. It was not the object of these countries to construct pavilions and kiosks—as they indeed exist in the East, though only as gorgeous architectural structures of pomp and luxury—and then to fill them like jewellery shops with all kinds of rare and costly specimens of Oriental wealth; but the Vienna Exhibition buildings of Turkey and Egypt were model edifices, which in design, construction, and interior arrangement represented the general style of architecture prevailing in those countries, and showed their practical advantages, for the purpose of being adopted or imitated elsewhere.

Fortunately the construction of these buildings was intrusted by both countries to the most competent persons, who entered upon the accomplishment of their respective tasks with enlightened views becoming the occasion. It appeared at first that the Turkish buildings would be eclipsed in importance by the Egyptian structures, but results proved that this was not the case. The principal effect of the Turkish style of building was not produced by their external appearance, but by the interior arrangement and decoration. The general management of the Turkish Exhibition was intrusted to the architect Mantani, a gentleman who, as "Court Decorator to the Sultan," has achieved great reputation in the construction and arrangement of the new palace buildings at Constantinople, by the revival of the pure old Turkish style of ornamentation and decoration, and on whom now devolves the important task of presenting to the European world a general view of the rich, artistic, industrial, and commercial productive power of Turkey.

For this purpose a number of buildings were erected, which, as types of Turkish architecture, corresponded pretty nearly with the several parts of the Egyptian group of buildings, so that, by reason of the contiguity of the groups of the two countries, a very interesting comparison of the peculiarities and differences in the Turkish and Egyptian styles was afforded to the visitors. The Turkish group consisted of a dwelling-house with bath, a bazaar, a café, another large building, which, as "Cercle Oriental," was intended to serve as a sort of casino or club for the Oriental visitors, and lastly of a large public fountain.

The Turkish dwelling-house was externally a very simple unassuming structure, which did not seem to bear comparison with the neighbouring edifices, but it was in reality an exact specimen of a dwelling-house of an opulent Turkish private gentleman, who, according to the custom of the country and the people, attaches little importance to the exterior, but so much the greater attention to the elegance and comfort of the rooms in the interior. During

the course of construction certain technical peculiarities of the Turkish style of architecture and mode of construction attracted general attention. The wooden framework was put together with extraordinary care and almost pedantic exactness. Inside and outside the beams were boarded with slit deal, and the surfaces were thickly plastered with mortar, so as to form hollow walls, which have the advantage of giving greater warmth. The flat roofs were covered with gutter tiles, which is the usual roofing material in Turkey from the palace to the lowest hut. The ground plan of the house and the adjoining bath was rather irregular, and little attractive, but it corresponded to the comfortable and convenient arrangement of the interior rooms, which gave the form, as it were to the exterior. The great number of rooms in the ground and the first floor, which one would hardly have expected to find in the building considering its small external size, were divided into the men's dwelling (selamik) and the women's dwelling (haremlik), each of which had its separate staircase. The rooms were not large but there were many, which very practically communicated with one another.

The interior decoration was rich and elegant, but not extravagant. There were first of all, the richly ornamented ceilings in the gentlemen's and ladies' rooms. These ceilings were distinguished by a diversified division of the space, as well as by the liveliness of the forms and the magnificent colouring of the ornaments, although the latter consisted only of Turkish letters, the different parts of which, however, were formed of plants and arabesques. The letters formed partly passages from the Koran, partly benedictions for the Sûltan. Harmonising with the ceilings was the splendour of the colours of the glass framework in the upper parts of the windows, whilst the lower parts were filled with wooden trelliswork. Very fine specimens of Turkish decorative art also were the marble works executed in white stone from the Marmora Islands, which were intended for ornamenting the rooms in the Haremlik, these consisting of cupola-shaped fountains of filigree work, from which sprung from nine to ten jets of water, and chimneys, also made of white marble, the columns and tendril-shaped relievos giving a very favourable idea of Turkish sculptor work.

The bath, which was built at the back of the house, contained in the ground floor the heating apparatus, and in the first floor two bath rooms, which were laid out with white marble, and were provided with very ingenious arrangements for heating by hot air and ventilation.

On the left of the house the bazaar was erected, a very interesting specimen of the Turkish style of building, the extraordinarily flat and compressed pointed arches, which were built of bricks with particular skill, forming a contrast to the high, small pointed windows of the Arabian architectural style. The wooden superstructure which was placed on the arcades of the bazaar served as a store-room for the shops in the ground floor.

Adjoining the bazaar was the Turkish café, a neat and elegant building, erected on an elevated terrace, and surrounded by a verandah. In this building also the exterior was distinguished by ornaments in the shape of railings, gables, &c. The beautiful plastic ornaments were enlivened by variegated but tasteful paintings. Behind the café, a kaik, one of the fantastic Turkish gondolas, was stationed on the so-called Heustadl water. The "Cercle Oriental," which was erected on the other side of the Turkish dwelling house, facing the Fine Arts building, was a pretty large edifice with a high open staircase. It was of an Oriental character, flanked by two pavilions, one decorated in the Turkish, the other in the Chinese style.

The most important Turkish edifice in an artistic point of view, was the fountain in the centre of the large garden ground, between the Industrial Palace and the Fine Arts building. It was an exact facsimile of one of the finest and largest monumental buildings of Constantinople, viz., the fountain of Sultan Achmed III., which is situated in the principal square of the Turkish metropolis, between the sublime Porte and the Aja Sophia. The erection of this monument in Vienna was also of historical interest, in so far as it was under Sultan Achmed III. (1703–30), that in consequence of the defeats it suffered, at Peterwardein and Belgrade, from the Austrian army under the command of Prince Eugène, of Savoy, the military power of the Osmans

ceased to be the terror of Europe. As a memorial of the association at the Universal Exhibition of Turkish culture with that of the Western world, Achmed III.'s fountain was not inappropriately chosen, as it was in the reign of this sultan that the introduction of European institutions into the Turkish empire commenced.

In its principal forms the fountain had a somewhat heavy and clumsy appearance, which was rather increased by the far projecting flat roof, with the unsightly cones which, however, are favourites with the Turks. The broad surfaces of the walls of the four fronts were, however, cleverly concealed by the marble ornamentation in relievo by which they were covered, which at the buildings in the Exhibition grounds was supplied by plaster casts after the original. These relievos belonged to the finest specimens of Oriental ornamental work, as well from their richness as from their variety of design, and the combination of imaginative freedom and realistic truthfulness in the execution of the botanical forms employed as ornaments. Each of the four fronts was differently decorated, the arrangement of the doors, niches, pillars, consoles, continuously changing, whilst the sculptures and relievoes had not the somewhat monotonous natural colour of the stone, but were tastefully painted and gilded. There were, besides, projecting at the four corners, round balconies, the high bay windows of which are filled in by gilded bronze trellises. The fountain itself was railed off in the interior of the building. One of the most beautiful subjects of the relievo tablets with which the fountain was ornamented consisted of vases with flower bouquets. Nothing could be more natural, and at the same time more artistic in style, than the large full roses, lilies, pinks, and fruit stems, every leaf and every branch of which was formed with life-like accuracy, and produced the impression of a piece of ornament executed with the most artistic care.

Between these ornaments ran, as in all Turkish works of art, the fantastic conglomeration of letters of Turkish proverbs and sayings. The golden letter formed on a blue ground had likewise an ornamental character, and the sense of these Turkish sentences agreed with the object of the building, praising the water in the interior, "the waves of which surpass the Semsem of Mekka " and the paradise well Selsebil." The Koran text, "All things live by " water," was frequently repeated.

The workmen who executed the Turkish buildings were not Turks by their nationality, but Greeks, Armenians, and Bulgarians. They employed only three kinds of tools—as peculiar double axe, a short hand saw, and a gimlet. But with these simple tools they produced more work of this particular kind than the European artizans; so that, notwithstanding their high wages of eight francs per day, and despite the travelling expenses, it was found advisable to engage 35 such workmen to come to Vienna to finish the Turkish buildings.

BRICK-MAKING MACHINERY.

The exhibits of brick and tile-making machinery at the Vienna Exhibition were but few in number, and we missed from the collection some of the best known and most largely used machines. There were, however, sufficient to form a representative collection of the principal nations exhibiting, and a general notice of these will prove of interest.

In the American section was a portable brick-making machine, exhibited by Mr. C. A. Winn, of Lockhaven, Pennsylvania. This machine is intended to produce a close imitation of hand-made bricks, and but a slight pressure is thrown upon the clay. It consists of a vertical pug mill, with which the clay is fed, and from which it is forced by a screw through an opening in the side of the mill into a box containing the pressure blocks. There are six of these blocks, of a Δ form, the lower surfaces being all in the same plane. They are connected to one common block, which is moved up and down in the box

by means of a connecting rod, worked off a crank at the end of an overhead shaft. Two vertical spindles, one on each side of the connecting rod, and attached to the block, work in guides bolted to the side of the pug mill, and insure a true motion to the block. The crank shaft is driven by a strap passing over the flywheel, and the driving pulley is on the same shaft as the bevel gearing actuating the screw in the pug mill. Flush with the delivery table, and at the rear of the box, is a narrow horizontal table, the full length of the box, and which is attached at each end to levers descending nearly to the bottom of the frame, and keyed to a transverse shaft, in the centre of which is a heavy balance weight. At the extreme end of this shaft, next to the flywheel, is a long lever of wood, curved at its upper end, which is almost in contact with the flywheel, and which is depressed at every revolution of the latter by means of a roller fastened to the wheel near its periphery. In moulding the bricks wooden boxes are employed, each box being divided into six compartments, representing the number of bricks made at each stroke of the machine. One of these boxes, well sanded to prevent the clay from adhering, is placed on the narrow horizontal table before mentioned, and as the revolution of the flywheel brings the roller into contact with the curved end of the long lever, movement is communicated to the table, which is thrown forward underneath the pressure blocks, pushing forward a box of bricks made during the previous stroke upon the delivery table. As soon as the next box is in place, the table returns to its normal position, the clay is fed down into the compartment, the pressure blocks descend, and a new set of bricks is formed, which in its turn is pushed forward by the advance of a third box, the superfluous clay being scraped off, and retained in the machine as the box comes forward upon the delivery table. In this manner the process continues without interruption, some 40 of the boxes being required to keep the machine going constantly. As soon as they are formed, the bricks are turned out of the moulds, which are fresh sanded, and placed again on the table prior to passing into the machine.

In one form manufactured, but not exhibited by this maker, the machine is mounted on a portable boiler, and carries a small engine, so that it is entirely self-contained. Such an arrangement is open to many grave objections, although it appears that a number on this system are working in the United States. In all cases portability is secured by mounting the machine upon wheels. A capacity of 40,000 bricks a day is claimed for the machine.

Of quite a different class was the only power driven brick-making machine which was in the British section of the Vienna Exhibition, manufactured by Mr. Thomas S. Derham of Leeds, under Morand's patent. It consists essentially of a strong vertical cast-iron frame bolted down to a bed plate, and of two inclined cylinders each 8½ in. diameter and 12 in. stroke, and illustrated by Fig. 1, Plate 216.

These cylinders are connected to the main driving shaft of the machine situated on the top of the frame, and carrying a worm as shown in the engraving, a flywheel, and a solid pulley. The worm gears into a large horizontal worm wheel fixed on the end of the vertical shaft, carrying the knives, revolving within the pug mill A. A strap from the upper pulley passes down to the lower part of the machine to a second pulley on the end of a horizontal shaft, on which is also a worm B gearing into the teeth formed around the periphery of the revolving table C. The lower face of the pug mill A is in close contact with the revolving table, as is also the cast-iron bracket and pressure plate D. The moulds for the bricks are placed in the table C, being made in segments so that they can, without difficulty, be removed from the table, when it is desired to alter the number or sizes of moulds. The machine exhibited contains seven moulds for the large German bricks which are formed by it. The moulds are simply rectangular openings, the same size of the bricks to be formed with blocks of cast-iron fitting them exactly, but free to slide up and down within the mould. These blocks are of considerable weight, and have brackets formed upon their under sides in which rollers are mounted. The rollers run freely around a ring plate shown at E in the drawing; the face of this plate is not in one plane, but varies according to the requirements of the machine. Thus immediately under the

pug mill, whence the clay is fed into the mould, the lowest level of the ring occurs, and the sliding block is consequently at the bottom of the mould. Beneath the pressure block D the path rises, and as the rollers are carried around it with the revolving table C, the bottom of the mould rises and compresses the clay contained, until it is sufficiently solid and compact; a pressure of about 50 lbs. to the inch is put upon the clay. In the pressure block there are formed two holes through which any excess of clay exudes and falls upon the table. Passing onwards, the roller path continues to rise, so that as the table revolves, the blocks rising also, force the newly-formed brick gradually out of the mould until it comes opposite the delivery table, when it is exactly on the level of the table, the rising path lifting the sliding block to a sufficient height for this purpose.

The brick is thrown off the table by an arrangement not shown in the engraving. In the front of the machine, and supported in brackets attached to the main frame, is a vertical rod near the lower end of which projects a finger, which is secured upon it. This finger is at a level corresponding to the under side of the worm wheel around the revolving table. A series of projecting studs, corresponding to the number of moulds in the table, are placed around the table under the worm wheel. One of these studs is shown at F. In turning round, these seven studs come, one after another, in contact with the finger on the vertical bar, pushing it outward. At a level above the face of the table is mounted on this bar an arm having at its extremity a broad plate; this arm slides to and fro, upon a bar projecting from the frame of the machine. To it is also attached one end of a strong rubber band, the other end being fastened to the main frame. This band serves as a spring, with a constant tendency to hold back the arm, a tendency overcome when the stud F comes in contact with the finger before spoken of, and forces the rod partially round. The flat plate on the sliding bar being exactly opposite the delivery band, and in such a position as to correspond with the highest point of the roller path beneath the revolving table, it follows that at the same instant that the brick is brought forward, and lifted out of the mould by the sliding block, the stud in the table throws over the vertical shaft, the advancing arm clears the brick away from the table, and places it on the delivery band, whence it is removed by hand. All the loose surplus clay upon the table is constantly swept away by fixed brushes into the empty moulds, advancing towards the pug mill, from which the moulds are completely filled. The clay, moulds, &c., are kept constantly lubricated. In conclusion we may mention that this machine, which justly attracted considerable attention at the Exhibition, can turn out from 15,000 to 20,000 of the large German bricks per day, or 25,000 English bricks.

In the British section of the Agricultural Hall, Messrs. E. Page and Co., of Victoria Iron Works, Bedford, showed a small hand machine for making bricks or pipes (see Fig. 2, Plate 216), which is of simple construction, cheap, and capable of turning out a good deal of work. In this machine the clay is placed in a box, one side of which—that opposite to the delivery—slides forward when the machine is in operation, and forces the clay out through the mould openings. The bricks or pipes thus produced are received upon a roller table provided with a hinged cutter, the wires of which can be adjusted at will.

In the German pavilion, at the rear of the Machinery Hall, devoted principally to the exhibition of refrigerating machines, fire-engines, and brick-making machines, was an excellent illustration of the latter in the exhibit of M. Jean Schmerber, of Mulhouse. It comprises two machines—one for the production of bricks, and the other for tiles. The former presents no speciality it is a good practical machine, with a double delivery, one on each side, at the bottom of the pug mill, the clay being delivered in a broad band upon a roller table, cut longitudinally as it issues by fixed wires, and afterwards transversely by another set. This machine which is illustrated by Figs. 3, 4, Plate 217, is also employed to form the blocks to be converted into tiles.

The machine first mentioned consists essentially of two parts—that carrying the matrices, and the press. The matrices are formed of plaster of paris, and are mounted upon a five-sided block *a*, see Figs. 3, 4 5, Plate 216, which is

placed on a shaft *p*, and revolves in suitable bearings in the main frame of the machine. Underneath each of these bearings is a screw, as shown, by means of which the matrix block can be raised or lowered so as to obtain a perfect adjustment. The shaft *p* projects beyond the bearings on each side, and on one end is mounted a pulley *m*, and on the other a disc *j*, having five recesses placed at equal distances apart around its periphery.

The press block *b* slides in the guides formed in the main frame, and contains in its lower side the iron mould corresponding in form to the plaster-of paris matrices before mentioned. A cam *k* mounted on a shaft *n* above, as shown, is in contact with the upper part of the pressure block, and in revolving forces it down upon the matrix. The shaft *n* extends outside the main frame, and carries at one end a cam *g*, and at the other a pulley *l*, and a large spur wheel. This latter gears into a pinion on the top shaft *o*, on which are flywheels, and fast and loose pulleys. It will be at once understood that the action of the cam *k* throws the pressure block *b* down, and exerts the required force for stamping the tile; but the means for bringing the block up again are rather peculiar. Turning in bearings formed in brackets in the main frame is a shaft *d*, which has keyed to it, midway of its length, a lever, shown in dotted lines in the side elevation, and the end of which passes through an opening in the lower part of the pressure block. This end is seen in the front view of the machine, and is marked *c*. Outside the frame, and at the extreme end of the shaft *d*, a second lever *e* is keyed, terminating in a roller *f*; this roller is always in contact with the face of the cam *g*, which is so laid out that it begins to throw forward the lever *e* just after the cam *k* has arrived at the position when the maximum force is exerted upon the pressure block, and it continues rising, forcing the lever *e* up, until the pressure block is raised. It is necessary that the matrix block should have such a positive motion imparted to it that one of its five faces carrying the plaster of paris mould should be always fair under the pressure block when the latter descends. This is effected as follows: the pulley *l*, driven by the same gearing that turns the main cam shaft, has upon its periphery a swelling *l'*, extending over one-fifth of the circumference. A loose strap passes over this pulley, and the pulley *m* on the matrix block shaft. For four-fifths of a revolution the pulley *l* runs free in the strap; during the remaining fifth, however, the swelling *l'* tightens the strap, and causes it to make one-fifth of a turn, and to bring one of the five matrices twice under the mould of the pressure block. It is, however, necessary that the matrix block should be securely held while the tile is being pressed, and this is done by means of the disc *j*. Upon the shaft *n*, and immediately over the disc *j*, is an eccentric, working within a link *h*, which is free to move up and down in suitable guides. The lower part of the link carries a pin *i*, as shown. The eccentric is set upon the shaft in such a position that each time the matrix block is thrown over one-fifth of a turn, the pin *i* descends and enters a recess in the disc *j*, retaining it until the pressure block begins to rise, when the pin is lifted by the eccentric, and the matrix block is free to be turned again through one-fifth of a revolution.

The action of the machine will now be clearly understood. In operation, a piece of clay, cut at an auxiliary machine, is thrown upon the matrix, and is carried round under the pressure block, formed, and brought forward; then it is taken off by hand, and a second piece of clay thrown on. In this way from 6,000 to 8,000 tiles a day can be made, and the plaster of paris matrices will last during the manufacture of from 10,000 to 12,000 tiles.

The same manufacturer exhibited a machine for making perforated bricks, well made, but presenting no speciality of detail. The clay is fed from the hopper through the moulding openings between rollers. The arrangement for cutting the bricks in this machine is unduly heavy.

The use of tiles for the covering of houses is still very common on the Continent, and the proper form and size of these tiles to be used for roof coverings are thus of great importance. The advantages of ridge tiles over the flat and corrugated tiles usually applied in Germany are now more and more acknowledged, and have secured for the former a steadily increasing use. The more important advantages of ridge tiles are less weight of the roof, as for one square metre 27 ordinary tiles, weighing each 1½ kilogramme,

are required, giving a total weight of 40½ kilogrammes, whilst the same space may be covered by 14 ridge tiles, each weighing 2½ kilogrammes, and representing a total weight of 35 kilogrammes, showing a difference of 5½ kilogrammes in favour of the ridge tiles. Besides being less dangerous in cases of fire, they are much cheaper, and require less manipulation in covering a roof. For the manufacture of ridge tiles are generally employed in Germany a pug mill, a gypsum press, a press for tiles, and a number of forms or moulds, A good example of a press for ridge tiles was exhibited at the Vienna Exhibition, in the pavilion for German brickmaking machinery, by Messrs. Edward Laeis and Co., engineers, of Trier, in Rhenish Prussia, and of which an illustration is given in Figs. 1, 2, Plate 217.

The construction of this press will be at once understood from the engravings if we simply describe the manipulations necessary for making ridge tiles. The iron forms or moulds have to be at first filled with good and well-mixed plaster of paris in such a manner that in the latter the form of the tiles can be made; this is done by pouring the plaster of paris into the moulds, placing the second half of the mould, made of tin and greased with oil, on the top of it, by putting the two half moulds then under the plaster of paris press, and screwing the latter slightly down. The moulds have now to remain under this press until the plaster of paris has become sufficiently hard, and after having produced in this manner one bottom and two top moulds, the manufacture of ridge tiles with the tile press may begin, for which manipulations four men and two boys are required. The well-mixed clay from the pug mill is cut by wires into cakes of a size sufficient for one ridge tile.

At each side of the press one man is placed, whilst two other ones work the wheel at the top of the screw. A lump of clay is placed now in one of the bottom moulds which is carried on a slide, and brought into the middle of the press exactly under the top mould, fastened with timber blocks to a cast-iron cross frame, which is moved by the screw spindle. The latter is then turned, and the top mould is pressed on the bottom mould two or three times in quick succession; the top mould is now raised, the bottom mould is removed, and a new one from the other side of the press is brought under the top mould when the operation of pressing is repeated. When the bottom moulds, which, as stated before, are carried on slides to which they are fastened by hinges, are drawn back from the centre of the press, they are turned over, and they strike then against the upright bars shown in the engravings. The finished ridge tile falls out of the mould on to a board, upon which it is carried to the drying chamber. Whilst one man on one side empties the mould, the other one has his mould filled with clay, and pushes it under the press. The press, which is shown in our engraving, is fastened to the foundations by four bolts, and has the following dimensions :—

	ft.	in.
Height of table from bedplate - -	2	9
Length of table - - - -	5	0
Width of table - - - -	0	10¾
Diameter of uprights - - -	0	2⅜
From centre to centre of uprights - -	2	2
Diameter of screw spindle - - -	0	3
Number of threads - - -	—	
Inside length of moulds - - -	0	16½
Inside width of moulds - - -	0	10½

During a working time of 11 hours, and with two men and two boys, 2,000 ridge tiles can be made with this press. The moulds have in the average to be renewed after 1,000 tiles have been pressed, often not entirely, however, but partly only. We may finally state that the press is well made and designed, and performs its work most satisfactorily.

A machine largely used in Germany far the production of clay pipes up to a diameter of 32 in. was exhibited by Messrs. Sachsenberg Brothers, of Rosslau-on-the-Elbe. It consists of a horizontal pugmill shown at A (Fig. 5, Plate 217) placed below the ground level, and containing a horizontal shaft,

armed with spiral blades. This shaft is driven by suitable gearing, and the clay is discharged through the opening *a* into the pit shown, in which revolves the lower drum B of an elevator. The upper drum B^1 is driven by worm gearing from a pulley, and the endless chain of the elevator carries at intervals, brackets *c*, *c*, which raise the lumps of clay, discharged from the pug mill, and cut into suitable sizes by the workman, to the platform overhead, and deliver it close to the pipe press.

This press consists of two large cast-iron rollers *d d* Figs. 6, 7 driven by gearing, as shown, which feed the clay into the receiver d^1, in a continuous stream, until it issues through the mouthpiece. The four columns *e e e*, carrying the platform, are provided at their inner edges with angle irons, that serve as guides for the table *f*, which has a small pulley placed at each angle, and having a V-shaped groove to fit the angle iron. The table is balanced by the two weights *g g*, that descend in the pit made to receive them, and shown in the drawings. To the lower side of the table are fastened two vertical standards *h h*, terminating below in a horizontal frame, the width of the pit, and the ends engage in guides, placed in the sides of the pit, as shown. On the faces of the standards are placed two racks $k\,k^1$, and near the ground level is a horizontal shaft k^{11}, carrying two pinions $i\,i^{11}$ gearing into the racks $k\,k^1$; at the end of the shaft k^{11} is a bevel wheel, gearing into another, driven by a shaft l^1, and a hand crank l^{11}; at the other end of this shaft is a small brake wheel *m*, which can be adjusted instantly by the lever *n*. This arrangement is employed both for raising and lowering the table, and for forcing the clay well around the core, which is of wood. The mouthpiece is enlarged in diameter, and formed to the contour of the socket of the pipe, and the form of the core corresponds.

The operation of the press is as follows:—The clay fed upon the rollers is forced through the mouthpiece of the press, filling the annular space left between the mouthpiece and the core, the table being fixed for a few seconds; it is then lowered, and the clay follows it, flowing in the desired form, until the proper length is obtained It is then cut off square by means of a wire. The table is then again lowered to the ground level, and the newly-formed pipe is placed upon a trolly, and taken to be burnt.

Of course the press can be used for different sizes of pipes by varying the diameter of the mouthpieces, and it can make from 550 to 600 lengths of pipes 3¼ in. diameter, the number decreasing of course as the size increases. A six-horse power engine is sufficient to drive the whole machine, pug mill, elevator, and press, and three men are required to attend to it.

Messrs. C. Schlickeysen, of Berlin, exhibited a brick-making machine, which has but few novelties of detail, the chief being the mode of lubricating the aperture through which the clay passes. A small quantity of water flows down through some fine wire gauze in the top of the mouth-piece, and keeps the inside of the mouth always moist. These machines are made with one, two, or four deliveries, so that a high duty can be obtained from them. In connexion with the one exhibited is an elevator for raising the clay from the lower level, where it is dumped by carts into a hopper, in which it is effectually crushed and broken up. Thence it falls upon an endless band, and is carried up to the top of the pug mill, into which it drops, and passes then through the ordinary process of manufacture. The drawings (Fig. 6 and Figs. 8, 9, 10, Plate 217) show the arrangement of this machine very clearly.

The Hertel Eisengiesserei und Maschinenfabrik Gesellschaft, in Nienburg, exhibited a large brick-making machine, in which the clay passes from the hopper between rollers, and thence is fed by a horizontal screw through the mould openings, where it passes upon a roller table, and is cut into the desired sizes by wires which divide the clay upwards from below.

Finally, we may mention as the last exhibit of this class in the pavilion, a small hand machine, which was shown by Spenger and Sterne, of Vienna. The box for receiving the clay is divided into two compartments, each representing a brick; the top of the moulding-box is carried by levers, one

on each side of the frame, the lower end of these levers being keyed on a transverse shaft, on which is also a long hand lever, balanced by a weight. On depressing this lever the top of the box descends, while the bottom rises, the clay being compressed between the two; the top is then thrown over, and the two bricks are delivered upon a small table forming part of the press. The price of this machine is a low one, and its capacity is equal to 2,000 bricks a day. One more exhibit of the class under consideration remains to be noticed to complete the series. This was in the Austrian section of the Machinery Hall, and is constructed by Mr. Louis Henrici, of Vienna. It is in all respects a good machine, of a similar type to that just mentioned as being shown by the Hertel Works, namely, a pair of rolls feeding the clay from the hopper upon a horizontal screw, and out through the mouthpiece in a continuous flow, the clay being cut longitudinally by wires placed diagonally outside the mouth, and transversely by a highly ingenious automatic arrangement.

It consists in the clay gradually flowing on to a supplementary roller carriage, and pressing upon a board held vertically by a detent. The carriage being free to move is of course pushed backwards on account of the pressure of the advancing clay against the abutment board. In this movement it carries with it also, a toothed wheel and rack, sliding along a revolving shaft, which has a clutch upon it at a suitable point. A corresponding clutch is formed on the sleeve of the wheel, and when this clutch engages with the other, the wheel revolves, giving a transverse motion to the rack, and through it to the cutting wires. As soon as the clay is cut through, the abutment board rises, and a balanceweight runs the carriage forward to its original position, while the bricks slide down an inclined plane, into trucks placed for the purpose.

As we have said, the show of brick-making machinery at the Vienna Exhibition was a very limited one, but in no case is it possible to point out any marked inferiority of design, whilst nearly all the machines shown possess considerable merit.

BUILDING MATERIALS AT THE VIENNA EXHIBITION.

The collections of building material, natural and artificial, were sufficiently numerous to prove of great interest to the engineer, the architect, and the builder; but it was difficult to obtain a clear and comprehensive idea of the exhibits of this class, from the fact that they were comprised in two groups, the 9th and the 18th, and because they were scattered throughout the various galleries, the pavilions, and the grounds.

The United States of America.

Specimens of a fine red sandstone, known as Connecticut freestone, were shown in the United States' section, a material largely employed in New York, and other towns, on account of its beauty of appearance, and ease in working it. The first sample shown was of a very fine quality, and small grain, rendering it especially suitable for mouldings and carved work; the second, a coarser stone, is adapted for building purposes, and the third, hard, and of considerable density, is largely used for foundations. Fifth and Madison Avenues, New York, show many examples of this stone, while it is employed upon numerous public buildings, such as the new State House in Hartford, Connecticut. Its comparatively low price, about half that of granite, has created for it a large demand, and renders its use economical, even when it

has to be transported to considerable distances. The Middlesex Quarry Company, Portland, Connecticut, contributed these specimens.

Blocks of yellow sandstone were also sent from Cleveland, Ohio, partially carved, in order to show the cleanness and facility with which it can be worked. Cubes of white, red, and black marble, pieces of granite from Burlington, Vermont, and a number of samples of red veined marble, from Champlain, completed the whole of the exhibits of this class, contributed by the United States.

England.

Of natural building materials, England presented but few specimens. Of these the samples of slate were especially worthy of notice, being by far the best of any in the Exhibition. The Welsh Slate Company showed two magnificent slabs, the larger of which was 9 ft. 10 in. long, and 6 ft. 3 in. wide, and it weighed 32 cwt; there were also some smaller ones weighing 20 cwt. In contrast to these masses, plates ·0393 in. thick were shown by the above-named, and by other firms. From the English colonies came a large and good collection. A fine variety of specimens of building stones were contributed from New Zealand by Dr. Haast, agent of the district of Canterbury, including sandstone, limestone, and clay. Queensland sent specimens of clay, and some good samples of marble.

Returning to England for a consideration of artificial building materials, we may first notice a number of specimens of cement contained in one of the cross galleries. This country is enabled to command a leading position in the sale of this material, thanks to the natural advantages it possesses in the inexhaustible quantity of chalk in localities exactly suited for the establishment of cement works, that is to say, in the immediate vicinity of water carriage.

The materials employed in the manufacture of cement, are chalk or limestone and clay, but the principal works are located close to chalk deposits, the clay being generally brought from a distance. In the cement works on the banks of the Thames the white chalk from the upper deposits, containing flint nodules, is employed, while in the works on the Medway, the gray chalk from the middle formation is used, containing considerable quantities of siliceous matter. The specific gravity of the chalk may be taken at 2·3 and the constituent parts as follows:

Lime	56·5
Ca. Acid	43·0
Water	0·5

The clay employed is dark blue in colour, and is free from sandy or ferruginous clays, as well as from vegetable matter. It is obtained in inexhaustible quantities along the shores of the Thames and Medway, as well as from the adjacent marshes, the following is an average analysis.

Silica	68·45
Alumina	11·64
Ca. Lime	0·75
Oxide of Iron	14·80
Alkaline matter	4·0

Two processes of manufacture are adopted. In one, the clay and chalk, mixed together in the proper proportions (on an average four parts of gray, or three of white chalk to one of clay) are thrown into a mixing mill, where they are thoroughly incorporated, and mixed with water, until the whole mass is about the consistency of cream. From this mill the mixture flows off into settling tanks where it dries and is removed by hand to hot plates; afterwards it is placed in kilns and thoroughly burnt, and finally is thrown into grinding mills, and reduced to powder.

The second, a dry process, is largely used on the continent. The chalk and clay are first thoroughly dried, and then reduced to a fine powder. To effect

this, stone breakers, notably Marsden's, are first employed, and afterwards a grinding mill, with vertical stones. The powder thus obtained is delivered alongside a vat containing an alkaline liquid, and close also to a vertical pug mill, which is employed to press the raw cement into bricks. The liquid in the vat is water, containing from 2 to 6 per cent. of calcined soda, and a quantity of freshly burned chalk. From 30 to 35 per cent. of this liquor is added to every 100 parts of dry powder, and into the pug mill are placed alternate measures of water and powder, the whole being intimately mixed in the mill, and forced out through a suitable opening in the bottom, in a continuous stream, 10-in. wide, by 5-in. thick. This stream is cut up into bricks as it issues forth, and these are placed upon boards, and removed to be dried, after which they are taken to the kiln, and finally ground. For further particulars upon the manufacture of cement, we refer the reader to Mr. W. F. Reid's excellent treatise upon the manufacture of Portland cement.

At the Vienna Exhibition, some of the leading manufactures in this branch of industry were absent. The Burgh Castle Portland Cement Company showed specimens of their produce, as well as the raw materials used; limestone, in bulk, and ground. The test which the cement resisted was remarkably high. Samples $2\frac{1}{4}$ in. in area ($1\frac{1}{2}$-in. square) after having been placed for seven days under water, broke only with a load of 1,250 lbs. This is a higher result than that obtained by Messrs. Lavers of Nine Elms, whose samples broke under 1,000 lb. load, the area being the same as above mentioned, and the test pieces having been kept under water for the same period. This firm showed a quantity of cement, packed for transport, as well as pressed blocks and plates. The colour is a fine white, and the grain on fracture remarkably uniform and compact.

Messrs. Johnson and Co., of London, exhibited a large variety of various cements, among others a yellow, so-called "vulcan" cement, for making pipe joints, and a brown mastic cement for joining slates, glass, &c. Two gypsum-like cements are in high repute for interior house work. The portland cement shown by this firm was of a light grey colour, and, judging from the specimens, of a superior quality. Test samples were shown, consisting of one part sand and two parts cement, which were broken, it was said, only with from 1,400 to 1,500 lbs., the area of the sample being $2\frac{1}{4}$ square inches. A testing machine put into frequent requisition accompanied the exhibits of this firm, as well as a number of cornices, mouldings, and well executed ornaments formed of cement and broken bricks, in the proportion of 1 to 2. There were, besides, several blocks of concrete formed of 9 parts of broken stone, and 1 part of cement, which showed great strength, and compactness; one of these stones was polished, showing a smooth marble-like surface.

The Scott Sewage Company exhibited an interesting series of specimens, showing their products in different stages of manufacture.

One of General Scott's productions is called selenitic mortar, and the process of production consists in mixing with the water used in the preparation of the mortar, a small quantity of sulphate of lime, in the form of either plaster of paris, gypsum, or green vitriol. These substances having been intimately mixed, the lime is added and ground with the water or sulphate into a creamy paste. The mixture is prepared in the pan of an ordinary mortar mill, in which the water and sulphate are first introduced, and subsequently the lime. After the lime has been ground for three or four minutes, the sand, burnt clay, or other ingredients are added, and the whole is ground for ten minutes more. By this invention, ordinary lime can be at once converted into a species of cement mortar, which sets rapidly and well, and can be used for concrete, bricklayers' work, or stuff for plastering at a cheaper rate than that made from lime in the ordinary way. From his experiments, General Scott finds the use of sulphuric acid to give the best results, so that this substance is used in preference to plaster of paris or gypsum, although the latter materials will answer for all practical purposes. Sufficient acid is contained in plaster of paris to effect the necessary chemical change, and to prevent the lime from slaking, which in effect is the secret of the whole process. The lime, by this means is enabled to take twice as much sand as when slaked, its fiery nature being brought under control. Any lime can be

made selenitic by General Scott's process, and the more hydraulic it is the better are the results obtained with it.

The invention is not only applicable to cement manufacture and mortar mixing, but its use extends to brickmaking. The bricks are composed of one part lime to eight or ten parts sand or burnt clay, and they are found to be ready for use in about ten days after pressing, without being burned. It is found that these bricks do not swell as is ordinarily the case from the slacking tendency of lime when not made selenitic. The proportions adopted for various purposes are as follows:—Mortar for bricklaying, water half a pail, plaster of paris, 4 lbs.; mix and add in the pan of the edge-runner two or three pails of water, a bushel of lime, and six bushels of sand; grind for ten minutes. For mortar for pointing, water, plaster, and lime as before, and add two parts chalk, slaked lime, or whiting, and two parts sand. For coarse stuff for plastering, same ingredients as for mortar, but coarser sand, and grind for five minutes only. For fine stuff for plastering, water, plaster, and lime as before, a bushel and a half of chalk, and two bushels of fine mashed sand. For coarse stuff on lath, add with the lime 5 lbs. of hair which need not be previously beaten. For rough stucco, same as for mortar, but four bushels only of sand. Plastering on walls can be done by this process as two-coat work, whilst ceilings can be floated immediately after the application of the first coat and set in 48 hours. The cements are very quick setting and they produce a very hard and finely finished surface.

We give in the following table (see next page) the results of a few experiments taken at random from the records of many thousands made under the superintendence of Mr. Gilbert R. Redgrave for General Scott, in order thoroughly to test the efficiency of his invention. The early results were so remarkable that they were repeated over and over again, and many others were instituted in order perfectly to satisfy himself of the correctness of his conclusions. The most searching trials, however, have only further demonstrated the importance of the invention, which is a thorough success and must prove invaluable in the constructive arts.

As it is often found in practice that tiles bedded in Portland cement leave their setting, Messrs. Minton caused a series of experiments to be made with selenitic cement in order to test its adhesive qualities in this respect. A number of their tiles were joined together in pairs crosswise in the same way as the bricks with two parts of ordinary Portland cement to one of sand. After allowing the joints to stand 14 days, a weight of 56 lbs. separated them, the cement in most cases coming clean away from the tile. With selenitic cement composed of one part lime to five of sand, the joint being 14 days old, it required a weight of 158 lbs. to overcome adhesion, and then the fracture took place completely through the cement, half remaining on each tile. With one of cement to three of sand, the breaking weight was 166 lbs., and with four of sand 165 lbs., the fracture in all cases taking place through the cement. These and the results given in the tabulated statement afford conclusive evidence of the superiority of the selenitic mortar over the ordinary compositions. We may add that a briquette of ordinary mortar composed of one part lime and two of sand, six months old, usually breaks at 70 lbs. or thereabouts.

Nature of Experiment.	Age of Joint or Sample in Days.	Composition of Mortar in Parts.		Breaking Weight of Joint or Sample.
	days.		sand.	lb.
Two bricks joined crosswise with selenitic mortar, giving an area of 20 square inches of joint.	14	1 Medway grey lime	3	255
Ditto - -	14	1 „	4	327
Ditto - -	14	1 „	5	340
Ditto - -	14	1 „	6	339

Nature of Experiment.	Age of Joint or Sample in Days.	Composition of Mortar in Parts.		Breaking Weight of Joint or Sample.
	days.		sand.	lb.
Two bricks joined crosswise with selenitic mortar, giving an area of 20 square inches of joint.	14	1 Lias lime -	3	259
Ditto - -	14	1 „ -	4	144
Ditto - -	14	1 „ -	5	160·5
Ditto - -	14	1 „ -	6	172
Ditto - -	14	1 Portland cement	4	217
Ditto - -	14	1 „	5	304
Ditto - -	14	1 „	6	206
Ditto - -	14	1 Lee's grey lime -	3	325
Ditto - -	14	1 „	4	336
Ditto - -	14	1 „	5	290
Ditto - -	14	1 „	6	303
Prism of selenitic mortar 2 in. × 2 in. × 4 in. long, and 3 in. between points of support.	209	1 Portland cement	3	668
Ditto - -	209	1 „	4	476
Ditto - -	209	1 „	5	344
Ditto - -	209	1 „	6	190
Ditto - -	177	1 Barrow lime -	4	740
Ditto - -	177	1 „ -	5	776
Ditto - -	177	1 „ -	6	698
Prism of mortar, same dimensions as before, but not selenitic.	177	1 „ -	3	440
Ditto - -	177	1 „ -	4	338
Prism of selenitic mortar, same dimensions as before	230	1 Lee's grey lime -	4	806
Ditto - -	230	1 „ -	5	722
Ditto - -	230	1 „ -	6	876
Briquettes of selenitic mortar, breaking area 1½ in. × 1½ in. = 2¼ square inches.	167	1 Portland cement	4	206
Ditto - -	167	1 „	5	149
Ditto - -	167	1 „	6	113
Ditto - -	132	1 Roman cement -	3	232
Ditto - -	132	1 „ -	4	250
Ditto -	132	1 „ -	5	124
Ditto -	132	1 „ -	6	89
Ditto - -	166	1 Medway grey lime	3	245
Ditto - -	166	1 „	4	147
Ditto - -	166	1 „	5	150
Ditto - -	166	1 „	6	108
Ditto - -	76	1 Halkin lime -	3	128·5
Ditto - -	76	1 „ -	4	197
Ditto -	76	1 „ -	5	99
Ditto - -	76	1 „ -	6	111

Referring now to the "sewage cement" of General Scott, it appears that lime and clay being the essential features of all hydraulic cements, the Scott process depends on their utilisation, at least for a part of the process. It is remarked that "The precipitation which ensues on their addition to sewage "water, is chiefly due to the combination of the lime with the carbonic acid

" and fatty acids which it finds there, but partly also to its affinity for the clay " which is added to it." From this we conclude that the lime has an affinity for the clay. "These substances, in subsiding, carry down with them, first, " some of the carbonate of lime, which was held in solution in the sewage " water, and small quantities of other soluble salts; secondly, the clayey " mineral matter in suspension; thirdly, the whole of the organic matter in " suspension, together with some portion of that which was in solution."

It may, therefore, be stated that the first step of General Scott's process is essentially that of precipitation. The result claimed in the deposit is, that in the mineral matters removed from the sewage water, and in the materials added to produce precipitation, substances analogous to the components of the limestones that are employed in the manufacture of hydraulic cements are present. After calcination, the products are perfectly similar, for all the organic matter is destroyed, the carbonic acid and water have been expelled, and nothing remains but lime and clay, together with such matters as alkaline salts, phosphates, chlorides, &c., common in ordinary hydraulic limes and cements, Practically the residue resulting from the calcination of this sewage deposit resembles Portland cement, which is usually produced by calcining three parts of chalk with one of clay. But in thus producing that cement a difficulty arises through the different powers of diffusion of the clay and chalk; the latter rapidly sinking, while the clay remains long in suspension. Hence it is difficult to make the product homogeneous. From this objection the sewage product is free.

Due to this fact, General Scott claims three especial advantages which result from his process, viz., intimate mixture of the compounds, rapid settlement of the sewage precipitate, and the presence of organic matter, which subsequently serves as fuel for the calcination of the deposit. It appears that in many, if not all, cases, the amount of the carbonaceous matter in the sewage sludge is so large that it may be employed for burning *per se*, and so removing all offensive matter, irrespective of any profit arising from the calcined results.

As a sewage scheme, therefore, General Scott's process may be briefly summed up as one that by precipitation throws down all the suspended and some of the soluble matter; and that the subsided residue may be converted into a cement useful for building purposes. The last result bears strongly on engineering and architectural requirements, for it involves the abundant production of a cement that hardens equally well in water as in air. It is evident, therefore, that such a cement would be a cheap one, not only for hydraulic, bridge, pier, and other such works, but also for ordinary building purposes.

It has been objected, that if the process were generally applied for sewage treatment, the amount produced would be more than the country could use. It is stated that the product in a week for each 1,000 persons would not exceed a little over half a ton. The company appeal to engineers and architects on the advantage that would arise in having in the cement a really good lime instead of the inferior material that alone can be obtained in many places. The use of the cement in building would practically convert a brick house into a stone one, "stucco villas" might be multiplied to any extent, but without the evils with which they are generally charged. We are glad to see that General Scott has noticed the fact that his cement would be of much value, not only as a lime manure, but also on account of a certain amount of phosphoric acid present. On the latter opinion as to its value we must differ, but if present in a minute extent it must be useful. The exceedingly comminuted state of the phosphate salts will be highly favourable for the rapid assimilation by the plant. In any case the farmer will get the phosphates for nothing, as we presume that the manure would be sold for lime value alone. The best specimen of native guano that we have analysed afforded about 1·8 per cent. of phosphoric acid, an amount almost identical with that obtained by the Rivers Pollution Commissioners' analysis from that manure.

Lastly comes the question of cost. On this point we have no sufficient evidence to guide us. It is stated by the company that from ordinary sewage

of the metropolis a ton of lime, costing 12*s.* 6*d.*, would produce a ton of manure worth (chemically judged) 25*s.* 6*d.* to, say, 30*s.* per ton. But so far as we can judge from the present views of the company, they prefer to stand on the ground of entirely removing all the present sanitary difficulties of sewage utilisation, and base the question of profit and loss as a matter of secondary consideration. The prudence of this course is self-evident, and speaks very strongly in favour of the chances of the process. It is hampered by no vain promises, and is left entirely on its own merits. An estimate, however, that is given of the pecuniary results of the cement department, assigns a profit of 3,000*l.* per annum for a town of 100,000 inhabitants.

Such is an impartial account of General Scott's process. As an immediate remedy for a crying evil it seems to us the best extant. It is certain in its action, which is more than can be said of any other sewage scheme. As such it must be a welcome resort to many Corporations and Local Boards, who are now almost in despair.

Turning now to the consideration of the industrial pottery exhibits, it is to be regretted that England, occupying so high a place in the class of industry, was so inefficiently represented. Examples of terra-cotta were shown by very few firms, but the exhibits that were there were well moulded and baked, although several other countries represented this material far better. Messrs. Jennings and Co., of Lambeth, whose staple exhibits were of a sanitary character, showed a few terra-cotta capitals and mouldings, and the same remark applies to Messrs. Doulton and Co., of Lambeth. This latter firm had a fine collection of bricks, chiefly hollow, of roofing and ridge tiles, cornices, voussoirs, kerbstones, and paving bricks, all well formed and strong, but comparatively light. One speciality by these makers was the "blue metallic bricks," made from Staffordshire ferruginous clay, the oxydation of the iron in which gives them their colour during the process of manufacture, but this colour may be altered at will, by modification in the mode of production. Messrs. Wood and Ivery, of West Bromwich, showed a collection of similar bricks.

Glazed flooring and wainscoating tiles were shown by very few English makers, which was rather remarkable, considering the wide adoption they meet with in this country. First on the list come encaustic tiles, made from caolin and various coloured clays, dried and pressed into the desired pattern, the glaze being obtained by feldspar. Messrs. Minton stand first in this industry, both in excellence of workmanship and design. The patterns were for the most part geometrical, and the colours employed are chiefly yellow, red, and brown. The exhibits of this firm at Vienna were in all respects excellent.

Mr. Robert Minton Taylor exhibited, besides encaustic tiles, a remarkable speciality, mosaic tiles. These consist of very small cubes of about one third of an inch sides, of variously coloured clay, pressed into form and great hardness in a suitable press, and afterwards burnt. These tiles have been largely used, and with great success, for mural and other decorations. Among the tiles for covering walls, &c. there were some exhibited by these firms, under the name of embossed tiles, of rather large dimensions, and ornamented with figures in relief upon a coloured ground. The most successful were those showing the raised figure in the natural colour of the clay, while the ground is covered by a dark blue or green. A third speciality was the majolica tiles, pieces of faïence produced from the whitest clay, and the drawings on which are either painted or printed, partly under and partly on the glazing. The ground of these tiles is generally a well chosen dead colour, with brightly hued ornamentation. The designs themselves were worthy of all praise, and in many cases Indian and Persian models had been copied; designs suitable at once for architectural decoration and for textile ornament.

In concluding this notice of the British exhibits in this special section we must remark that, although as we have already stated, the number of objects was small, the selection was admirably made, and materials and workmanship were alike deserving of commendation.

FRANCE.

This country showed, both in the Industry Palace and scattered through many annexes, some fine exhibits of building materials, natural and artifical.

Commencing with the former, there was a very large collection of slate exhibited by the Société des Ardoisiéres de Rimagner. This company erected a special building to show its beautiful material, and the various uses to which it is applicable. In the lower part of this pavilion the walls were panelled with different kinds of roofing slates, arranged according to their thicknesses and colours. The thicknesses varied from $\frac{1}{8}$ in. to $\frac{3}{16}$ in., and the colour ranged from a full red to a mild clear blue. The roof of the pavilion showed other applications of the slate of the Ardennes, such as elegant bordering, strong ridging pieces, &c. One special production, made in a tasteful way from the darkest and most uniformly coloured slate may be mentioned. The slabs are highly polished and are partially covered with enamelled paintings, the bright colours of which form a striking and agreeable contrast to the dark background of the stone. These pieces are adapted for stone fittings and decoration.

MM. Livet, Fils, et Cie., of Paris, showed a fine collection of sand and limestones. Some of these are worked and polished, exposing a fine grain and a pure white colour. Both classes of stone from the quarries this firm represent have been used largely in the palatial buildings in Paris, and they are, moreover, exported in large quantities to Holland, Belgium, and Germany. Sandstones of fine quality were shown by M. Maximilian Panguet, of Savonniéres and Brouvilliers, in the Department of the Moselle, and the quarries of MM. Favre et Cie., St. Paul (Drôn), furnished samples of an excellent fine grained sandstone of a beautiful white hue, and peculiarly adopted for architectural decoration. The material is known as the Pierre de Paris and was shown in large blocks.

But French marbles were far more numerously represented than any other stone, both as specimens in the block, and in their application to industrial and ornamental purposes. On the north side of one of the French galleries there were some magnificent masses of this material, of various hues and markings, but wonderfully uniform and beautiful in texture. Each sample was polished on two sides. They were exhibited by MM. Déraillié et Cie., of Paris, and were especially adapted for architectural purposes. The same firm owns establishments in Brussels, Cette, and New York, and their quarries are distributed through France. Those of Félines-Hautpoul (Hérault) furnish the fine Griotte d'Italie and Griotte-Compan, of a dark red hue, with darker spots and white veins. From the same quarries comes the Languedoc, a variation of the above-named stones, of a similar colour but with large white spots and dark red veins. From quarries in the Hautes Pyrénées is obtained a class of marble of a light red tone, with spots of a darker hue. Again, out of quarries near the mouth of the Rhône is taken a marble known as the Brèche Impériale, light in colour, but clouded with veins of red and grey, here and there spotted with yellow and red, and darkly veined. The Grande Antique, from La Rochelle, has an almost uniform red hue. This, exhibited in specimen by some other firms besides that of MM. Déraillié, is suitable for large works of art. Equally beautiful were the blocks from the Basses-Alpes, the polished surfaces of which were almost uniform in colour, a dark green, broken only here and there by veins lighter and darker than the prevailing hue. In the Haute-Garonne are quarries of a pure white statuary marble, called Blanc de Béat, and sufficiently fine to compete with the higher qualities of Italian marble. So far the exhibits of MM. Déraillié et Cie., and we may pass on to mention some other classes of marble shown by other exhibitors, and especially the transparent onyx marbles, white and yellow, and variegated with yellow and red markings. These were not of French origin, but were imported from Mexico, and were exhibited by MM. Maliannon and Favier. Specimens of a similar stone from Algiers were also shown, but these did not compare, either in size or quality with the large slabs from the Mexican quarries.

Turning now to the exhibits of artificial building materials, we commence in the Industry Palace, with specimens of majolica tiles. Although neither

the manufacture nor the application of these tiles is so largely developed in France as in England, many examples of high excellence were to be seen. Those by M. T. Deck, of Paris, may be especially mentioned, for bright colours, heightened with a peculiar glaze, and the elegance of his designs, most of which are Persian. A second well-known exhibitor was M. E. Collinet, of Paris. His designs, like those just mentioned, are mostly copied from Eastern originals, and he has succeeded in making larger tiles (*panneaux*) than any other firm. Two different kinds of enamel are found in these tiles, the first, a simple glaze, covering the tile, with a smooth surface. The second is adapted particularly for the larger *panneaux*, and is called *Email-cloisonné*. A white glaze is first placed over the tile, and on this, the design is painted in black. During burning the enamel retires, giving an appearance of relief to the drawing, the colours of which are heightened. Much as the finish and design of these tiles deserve praise, it is a pity that their high price renders them only suitable for exceptional application. For example, a panel 3 ft. 3 in. square, prepared with the *Email-cloisonné* process, costs 18*l.*, and others are priced at 14*l.*

In the coarser branches of this industry, and in the manufacture of bricks, France exhibited practically nothing. The latter were represented by a so-called "*brique en conjonction*," shown by M. E. Pavey, of Méziéres-en-Brennes (Indre). The bricks are hollow and formed with a dovetail for fastening to the adjoining brick. Several forms were shown by the exhibitor. 1. A common brick, with dovetailed connexions. 2. A special form for partition walls. 3. A compound brick for curved work, these being formed with different radii, and particularly recommended by M. Pavey, for chimneys, water cisterns, grain tanks, &c. 4. Voussoir bricks, with six connecting points.

Among the French cements were some very remarkable products. Boulogne cement, well-known in France, was exhibited by its original manufacturers, MM. Demarle, Lonquety, et Cie. The natural colour of the cement is yellow, but blocks, &c. made from it are of a light blue tone. The excellence of this material was shown by its products. The various blocks were extremely smooth, and quite free from flaws and cracks. Among other specimens were plates 6 ft. 6 in. by 3 ft. 3 in., and ¼ of an inch thick, with perfect surfaces. To prove the strength of this cement, the following experiment was made. Thirty large bricks were united with the cement, and to a beam, so that the surface of adhesion was equal to the area of one brick. These were fastened to the end of the beam, which was placed horizontally, the pile of bricks depending from it. Samples of the hydraulic lime of Lapaye-du-Theil, long since widely used in France, and exported in large quantities, were also exhibited. The works where this lime is produced are very large. In that of Laparge (Ardèches) about 18,000 cube feet are burned per day in 34 furnaces, employing for this purpose from 80 to 100 tons of coal. The burnt stone is brought into sheds to be slacked, and in order to accelerate the process, it is submitted to the action of steam jets. Ten days are usually required to turn the mass to powder, which is then passed through bolting machines. The residuum in the bolters, which is not rich enough to fall to pieces, is then ground, and is employed for cement. This lime is largely used for harbour work, and MM. Laparge exhibited blocks of concrete taken from 14 harbour works, in France and elsewhere. Some of these blocks had been under water for more than 25 years, but showed no alteration, either from the mechanical or chemical action of the sea. In illustration of their industry, MM. Laparge exhibited also specimens of the limestone used by them, of slacked lime, and of the same after it had been bolted, as well as some packed for transport. Till within the last few years the slaty residuum before mentioned was thrown away as useless, experiments which had been made with a view of utilizing having shown discouraging results. As the production increased, however, the amount of this residuum became enormous, and fresh trials were conducted, resulting in the production of an excellent cement, samples of which were exhibited, as well as pipes, some 6 in. in diameter, made with it mixed with sand in about equal proportions by weight. These pipes have a very smooth, dense surface.

Bricks also are formed of it and sharp river sand, in the proportion of about one of the former to three of the latter.

Laparge's cement is largely employed by MM. F. Lauzun and Co., of St. Ardéal (Ardèches), for tiles. After many trials these gentlemen obtained a series of colours suitable for the purpose, and now produce fine tiles, well coloured, and very suitable for paving. They wear well, and are comparatively cheap. Imitations of various marbles are also very successfully produced, adapted for pedestals, columns, steps, &c.

A material employed largely in Paris, for architectural decorations, is the "*carton pierre*." MM. Hardouin and Lefebre, of Paris, exhibited specimens of this material. The production is as simple and cheap as that of gypsum ornaments, it takes colour better, and is claimed to be altogether more suitable.

In concluding this notice of French building material exhibits, those of fire-proof substances may be mentioned. These were represented by two firms. The *Compagnie Parisienne d'Eclairage et de Chauffage par le Gaz*, exhibited retorts, and fire-clay bricks made by them, not as an article of trade, but for their own uses. The former, however, showed many external cracks, and could not be viewed without suspicion. The bricks were not of good form, and in appearance did not compare with others exhibited, although the clay might have been excellent. Finally MM. Bousquet et Cie, of Lyons, showed some examples of fire-clay bricks, that appeared good.

Belgium.

This country made a very fair show in building materials. As in the French gallery, the Belgian court contained some very fine blocks of marble and tables of specimens. From the province of Namur, came some very beautiful kinds. One of these known as the Grive Gérard was of a light gray tone, with small black spots distributed regularly over the whole surface. Another, the *Lilas*, is of a brighter gray, with white and very dark spots. The *Florence* has a reddish gray colour, with brown spots; that known as the Coquille is bluish-black, with light spots, having a contour like that of mussel-shells, and the *Marbre Bois*, showing a fibrous pattern on a black ground. The pure black marble of Mazy-Galzines, exhibited by De Taiffe Devnage, is noted for the facility with which it can be worked, black marble being often very brittle, and therefore wrought with difficulty. The superior qualities cost from 6*s.* to 15*s.* per foot. The lower classes costing about 2*s.* 6*d.* per foot, are very suitable for paving purposes.

MM. Vincent Fils of Basécles (Hainaut) also exhibited samples of marble, as did MM. Puissant Fréres of Mer le Chateau (Hainaut). Some of these exhibits, however, came from Italian quarries, owned by the firms just named.

A large collection of slate was shown by the Société des Ardoisiéres de Warmifontaine. It exhibited roofing slates from Luxembourg of 15 different forms and classes. The first quality is cut in pieces $\frac{1}{8}$ thick, the second is $\frac{3}{10}$ in. thick.

Among the artificial building materials may first be mentioned those by the Compagnie de Marbre Universel of Brussels, who showed a large collection of columns, steps, paving, ornaments, &c. Endeavours were evident to imitate as many colours as possible, but the result was a lamentable failure. It may be stated, however, that claims are made for this material to place it before marble for durability, beauty, utility, and cheapness. The last claim was made good by the exhibitors' price list.

Fireproof material was conspicuous in the Belgian section, the leading manufacturers in that country having been represented. The province of Namur, especially in the locality of Ardennes, possesses large supplies of excellent fire clay. The Société Anonyme des Terres Plastiques, et Produits Refractaires d'Ardenne, is the oldest representative, we believe, of this industry in Belgium, having been famous in 1836. This Company exhibited a very interesting collection of the various kinds of clay with which it deals, varying in colour from an almost pure white to a very dark bluish grey and reddish-

brown. The quartz employed is of three kinds: the first is a compact stone; the second a conglomerate, coarse of grain, and of a grey colour, which becomes reddish when burnt; the third is of a fine grain, and also grey, turning to a bright red when burnt. The finished bricks, the superior quality of which is well known, are noted for their cheapness, and they are exported in large quanties to France, Germany, Austria, Russia, Italy, &c.

The price of the unburnt clay is about 12*s.* or 14*s.* 6*d.* per ton, burnt, it rises to 28*s.* or 30*s.* The price of the quartz is some 15*s.* per ton. The finished bricks, suitable for blast furnaces, gas furnaces, Bessemer converters, &c., is about 28*s.* per ton. Hearths, &c. &c. reach 2*l.* 12*s.* per ton. The gas retorts of this company are of excellent make and quality, and are remarkably cheap.

The *Société des Produits Refractaires de St. Shirlain* (Hainaut), had a very similar exhibit to the foregoing with which they also competed in quality. Statistics of prices, &c., were however wanting, which was not the case with the exhibits of Messrs. Smal and Co., which were of high excellence. The following data may be of value, as giving the current prices per ton, delivered at the works in Ardenne.

Raw clay varying according to quality from 11·20*s.* to 16*s.*

	£	*s.*	*d.*
Raw Clay burnt - - - - - -	1	4	0
Fire proof bricks for puddling heating furnaces &c. -	1	12	0
Bricks for blast furnaces - - - -	2	0	0
„ „ inner linings - -	2	4	0
„ boshes - - - - -	2	12	0
Hearth and floor blocks for blast furnaces - -	3	0	0
Hearth blocks for welding furnaces - - -	3	4	0

M. Dor, director of the works of Amprin, in the province of Liége, has introduced the use of powerful hydraulic presses in the manufacture of fire clay bricks, which has reduced the prices, and by which a denser material is obtained. Specimens of such bricks were exhibited.

Holland.

The brick making industry of the Netherlands was represented by some large collections. Most of the bricks exhibited were of very small size, and often not well-formed. The corners were rounded, and the surfaces covered with a rough layer of sand. They appeared, however, to be well burnt throughout without any vitrifaction on the outside, and are of a close texture and very hard. The price depends largely upon the colour, which varies from light yellow to a dark reddish brown. Messrs. Van Hankeloom and Co., of Kamer, near Utrecht, make excellent bricks, and exhibited various types. The largest size is $8\frac{5}{8}$ in. × $4\frac{1}{8}$ in. × 2 in., and vary from 20*s.* to 2*l.* per 1,000; the second size is $6\frac{1}{4}$ in. × $6\frac{7}{8}$ × $1\frac{9}{16}$ in., and the price lies between 8*s.* and 10*s.* per 1,000. Messrs. Henkeloom also showed glazed bricks, but the colours were not good, a dull purple or green being the most prevalent.

Similar types, but of somewhat different sizes and prices were shown by Mein. Claasen and Plaat of Velp, near Arnheim, and also by the manufacturer M. De Lint, of Delft. The clinker bricks of this firm, are suitable for paving, and this material is in great demand in Holland for the purpose, stones being costly. It is worthy of remark that the prices of the machine-made bricks are 2 or 3 per cent. higher than those made by hand.

Roof tiles were shown by Mr. Visser, of Workum; they were rather slight, and of a good colour. In Mr. de Lint's collection, mentioned above, were also small wall tiles, of the orthodox Dutch patterns, and of white, pale blue, and lavender colours. The prices of these vary between 3*l.* and 4*l.* per 1,000, the size being 5 in. × 0 in.

Mr. Ravesleign of Utrecht, makes millions of these tiles per annum, with a great variety of patterns, most of them primitive rather than elegant. The prices are very low from 8 to 12 centimes apiece, measuring 4·921 ins. square. The subjects of ornament are chiefly landscapes, figures, &c. Tiles of better quality were exhibited, costing from 3*l.* to 3*l.* 5*s.* per 1,000.

Denmark.

This section contained little of building material. Some pieces of terra cotta deserve passing mention. Moulded stones in this material by Mr. Meyer, of Kolding, had not much to recommend them, either in quality or price. Some very excellent roofing material tiles were exhibited by Messrs. Erichsen and Co., of Copenhagen. It was solid, flexible, and of close texture, and appears to fulfil all necessary conditions. Indeed a long experience has shown that as a roof covering, Mr. Erichsen's fabric is very successful. A model of a roof covered with it was exhibited, and the material was shown in three different colours, black, white, and red.

Sweden.

Here also there was little to claim attention. From a good collection of specimens however, sent by the Swedish Geological Society, the riches of that mountainous country, in building materials, was very evident. The granite quarried in Sweden is of excellent quality, and is largely exported. The columns of the famous bridge in Thorn and Tilsit, are of Swedish granite.

Porphyry, marbles, limestones, and many others, existing in enormous deposits, were also shown by small samples, contributed by the Society, chiefly with the object of explaining the splendid geological map of Sweden that was exhibited. No fire resisting materials were shown, although very large quantities of them are absorbed by the iron works of the country, and much is of home manufacture, although a very considerable quantity is bought of England.

Mr. Lundberg of Lomma, near Malmo exhibited some good cement, the products of a new industry, established, we believe, by the exhibitor on a large scale.

Italy.

Italian building materials were well and very completely represented. That country is gifted with an inexhaustible supply of the richest and most varied supply of stone, for useful as well as for decorative and art purposes.

Besides individual exhibitors, the Italian Ministry of Agriculture, Industry, and Trade exhibited a fine collection of stones, commonly quarried and worked in Italy. Under the title of building stones (*materiali da construzione*) there were no fewer than 245 different samples of granite, limestone, clay, cement, asphalte, &c. The numerous kinds of marble ranging from pure white statuary to black, and between these extremes, all hues and combinations, were grouped in the same exhibits under the title of *materiali da decorazione*. This second division contained also granite, porphyry, serpentine, &c., indeed, all all stones applicable to decorative purposes. It included as well coloured earths, and clay products.

These latter were represented by private exhibitors, but unfortunately they were but few. Messrs. Anghi Boni who possess a reputation for the manufacture of terra cotta, showed some well made objects, but deficient in surface finish. The colour too was bad, and deteriorated during the six months of the Exhibition.

Messrs. Resignani & Co., Messrs. Galatti and others exhibited specimens of ordinary bricks. Mr. B. Mazoni of Daguacavello, showed paving tiles, inlaid with coloured clays, which suffered greatly during the six months of exposure, a fact that said little for their value. Specimens similar to all these, were also found in the admirable collection of the Ministry above mentioned.

It is to be regretted that the manufacture of majolica tiles for walls and floors, and which forms a great industry in the south of Italy was so inadequately represented. The collection of the Ministry included some examples from Salerno and Naples, with good and simple decorations, and some from Florence with impressed decorations. In addition Mr. Fayani of Salerno, exhibited a small number of his tiles, executed in a very primitive fashion, but very cheap, the price being 15 centimes per square 6 ins. x 6 ins.

Fire-resisting material is produced to a very limited extent in Italy. Messrs. Biagi and Sentimelli of Florence, contributed some trifling exhibits of this class.

Spain.

Despite the serious internal agitations distracting Spain, that country made, comparatively, a very fair show at the Vienna Exhibition, and in this department of building materials, offered exhibits of considerable interest. In the pavilion for mining industry, and its allied branches, there were many fine specimens of natural building stones, whilst there were also numerous collections representing in great variety, the resources of Spain in this respect. Amongst them, marbles of various colours and markings predominated. El Institue Balcor, of Palma, for example, showed a very fine collection of marbles, quarried in the Balearic Islands, and largely in demand both for home use and for exportation. The commissioners of Burgos, Badajoz, Madrid, &c., also provided similar collections. Mr. E. Nunez of Cogolludo, Guaddlajaro exhibited magnificent specimens of pure alabaster, and from the same province was sent examples of fine dark coloured slate. Many specimens of hydraulic limes and cements were also to be seen.

Artificial building materials, including walling and floor tiles, were represented by several well known makers. Mr. Nolla of Valencia produced very good encaustic tiles, although they could not compete either in finish, or number or brilliancy of colours with those of English manufacture. Mr. Nolla's tiles, we may observe, are very largely exported to Italy and South America. Mr. L. Reus of Catalonia, showed white, brown, and black tiles, carefully made. This industry in Spain is evidently an imitation, and on the whole a poor one, of English production, but in another branch more originality is displayed,—the fabrication of fayence friezes. The walls of the Alhambra form such a mine of wealth for imitators, that it is no matter for surprise that several firms copy freely those old designs. Amongst them we may mention Messrs. Soto y Tello of Seville, whose products are used for restoring the Alhambra, and used very successfully. The predominant colours are, white, green, blue, and black. The designs form a sort of mosaic, consisting of triangular and prismatic figures. The execution however, is often far from good, and leaves much room for improvement in finish. It may be added that the original designs of Messrs. Soto y Tello, contrast very unfavourably with those copied from the old originals. Messrs. Novella and Garcés of Valencia, exhibited tiles with ornamentation in relief, corresponding to the embossed tiles of the English section. Some of these were extremely well executed, especially those showing regularly disposed rectangular depressions whilst the colours are well brought out by the different glazings employed. The price of these tiles however, was comparatively high, being 1·25 francs each while the plain ones were only 25 centimes, and those with ordinary relief ornaments 37 centimes each. They were about 8 inches square.

Portugal.

Although Portugal like Spain made quite a good display at the Exhibition, that country showed little coming within the limits of this section. The alteration of the laws affecting mining industries in Portugal, made in 1852, has produced a considerable alteration in those industries, the benefits of which have been especially felt during the last ten years. At present a large number of mines and quarries are worked in Portugal, and from some of the latter came specimens of marble, exhibited by the Société pour l'Exploitation des Marbres, d' Estremas. Mr. Malheiras of Lisbon, Mr. Novello of Vianna, &c., showed collections from various parts of the country. Mr. Francisco Ennei had a very fine series of slates from the district of Porto. These show throughout a homogeneous structure, and are of a remarkably dark colour, some samples being almost black. The exhibits included several large plates, one of which, about 2·in. thick, measured 6 ft. 7 in. by 11 ft. 9 in. Cisterns and other built up receptacles were shown here formed of slates, and the same exhibitor had a good collection of roofing slates.

Of the artificial productions coming under this section, Portugal showed but little. There were some good samples of bricks, light red, sound, and well baked; roofing tiles, of various forms, and colours, yellow, black, and red. All of these were well made, and were shown both glazed and unglazed. Finally, may be mentioned some roofing tiles with holes in their edges for attaching them on the roofs.

Germany.

No other country, with the exception of Austria, could compare with Germany in the extent and completeness of exhibits of building material. The Mining Commission of Alsace and Lorraine contributed a fine collection of specimens from the quarries of those districts. It comprised about 180 samples of granite, gneiss, and porphyry, with different kinds of sandstone, limestone, and marble. M. Maximilian Ponguet, proprietor of numerous quarries, and whose name has already been mentioned in speaking of the French section, exhibited large blocks of sandstone, and a hard fine-grained limestone. Half the products of this firm, which has been established since 1846, are bought in the German market, the other half being distributed throughout Europe. Mr. Franz Ritterrath, of Trier, showed a good, uniform yellow sandstone, from this district, partly rough, and partly finished. From the quarries of the Unstrut Valley were sent Unstrut sandstone, a fine material, homogeneous in grain and colour. The quarries near Nebra were worked in the 10th century, and the stone is still largely used, especially in the North of Germany, for building and decorative purposes. The columns in the façade of the palace of the Crown Prince, and much of the ornamentation in the chief buildings in Berlin, are of this stone. Mr. C. A. Merkel, of Halle-upon-Saale, exhibited a large lion carved out of this dark yellow sandstone, quarried from the vicinity of Halle. The same firm also sent a pedestal carrying the bust of the Crown Prince, and made out of a grey sandstone.

The granite exhibits of Mr. C. Kulmiz, of Saarau, Silesia, attracted considerable attention, on account of the excellence of the material. They included a slab 16 ft. long by 12 ft. 4 in. wide, and $7\frac{1}{16}$ in. thick, and a column 21 ft. high, carefully wrought and surfaced. Near these was the best collection of slate in the German section, sent from the Saxe-Meiningen slate quarries, and from the private owners in the same vicinity.

The slate industry of Lehesten, whence these specimens came, has been carried on since the 10th century, and it has had always a high character from its fineness of grain, and evenness of cleavage, plates only ·039 in. being produced from it. The surfaces are very smooth, and very suitable for roofing. The average thickness of these slates brought into the market is about $\frac{3}{16}$ in. Its durability is attested by the many ancient buildings in which it is employed. Thus a castle (Fränkische Leuchte) near Hildburg, was roofed with the Lehestener slate in 1563, and it still remains in perfect condition. The unusual power of resistance to the destructive action of the atmosphere, arises from its chemical formation, which according to Frick's chemical analysis is as follows :—

Silicic acid	64·58
Alumina	17·10
Oxides	13·11
Carbonate of lime	0·53
Water	4·08
Carbon	0·60

The colour is uniformly dark blue. The price of this slate is exceedingly low, so that it commands a large sale. Mr. Carl Ortel also exhibited many excellent samples from the same district.

There remain to be mentioned the light-coloured slates from Seesen, sent by Mr. Schoett, and samples of almost black slate from Berleburg, exhibited by Mr. Kreuser, of Cologne, and some other specimens by Rhenish and Bavarian exhibitors.

The German marbles exhibited did not possess the variety and fine colours of the French, Italian, and Belgian stones. The Actien-Gesellschaft West-

phalische Marble Works from Allagen, near Soest, exhibited a collection of specimens, amongst others several turned columns, which showed a good effect on the curved surfaces. These works are well known in Germany, and supply the market largely. The value of raw material worked up yearly by them amounts to 20,000 thalers. The products of the Mecklenhausen Marble Quarries were represented by six samples, two of which were of remarkable beauty, one having a pure white body, with pink flocculent marks, the other of a brown hue with ultramarine lines.

Amongst exhibits of wrought marble, those of M. Schleicher, of Berlin, showed remarkable skill.

The Saxon Serpentine Stone Works, of Zöblitz, supply a large and varied quantity of stone for ornamental and archichitectural purposes. Although the application of serpentine is of great antiquity, being found in the works of Norman and Florentine architects, it is almost universally seen in very small pieces. The company above named, however, produce large blocks, and veneers for covering common stone, and their exhibits showed the high degree of perfection at which they have arrived in this process. In general, the serpentine of Zöblitz is of a dark green colour, and of conspicuous appearance in architectural decoration. The same firm showed also Mosaic, well executed, in black, green, red, and yellow, as well as wood inlaid with serpentine, in which an excellent effect was produced.

Proceeding now to artificial building material, some important exhibits of imitation stone were shown by the German-Marezzo Marble Company, of Charlottenburg, which erected a pavilion in its own material to the north-east of the great German annex. Although, as in the case of the exhibits of Marbres Universels in the French section, many unnatural colours and combinations are seen, these makers are far more successful in their products, which have been considerably employed with good effect for public buildings in Berlin and elsewhere. So far as observation extended, the work of these exhibitors resists the changes of temperature and exposure with success.

A novel and excellent imitation of stone is the "Cajalith," of Mr. F. A. Schmidt, of Dresden. The composition of this material is kept a secret by the inventor. In appearance it is fine-grained, nearly white, and when wrought appears almost like marble, or the fine Saxon sandstone already mentioned. Mr. Schmidt's exhibits showed that the material is quite plastic when first made, and can be moulded into any desired form, but shortly after it sets it becomes extremely hard, and can be worked like natural stone. Cornices, balustrades, steps of staircases, pedestals, &c., were exhibited, beside a number of art subjects, which, collectively showed the variety of purposes to which the material can be properly applied. Cajalith also can be made of any desired colour, and the inventor, taking advantage of this property, produces and exhibited several samples of good imitations of natural stones. The Mosaic work, however, that was shown was very imperfect, and was damaged by exposure to the weather. The produce of this material is now assuming quite large proportions, about 50 tons a month being produced at the exhibitor's works, and the demand is constantly increasing.

Messrs. Herfeldt, of Plaidt, near Andernach, exhibited some tufa, a volcanic material, found in the vicinity of the Laacher sea, near Andernach, in very thick deposits. It was applied by the Normans to many building purposes, and is now largely employed in making hydraulic lime of great hardness. According to Dr. Kyll's analysis the blue tufa is formed as follows:—

Silicic acid	52·2
Alumina	15·2
Sesquioxide of iron	11·4
Lime	5·7

The balance being magnesia, alkalis, and water. Its value for hydraulic lime is proved not only by the great number of ancient examples extant, but by an extended modern practice. Its low price has created a large export trade to Holland, Belgium, the east of Germany, &c. The stone is generally supplied in blocks of about 22 lb., for as the tufa is found in layers separated by stones containing no hydraulic properties it is preferable to purchase it in blocks than ground.

Messrs. Herfeldt's exhibits consisted of a pedestal, on which stood two vessels, one containing salt the other fresh water, with specimens of the mortar, which were placed from time to time in the water, to give the visitor an opportunity of judging the result. Setting takes place slowly, but the mortar becomes ultimately of great hardness.

The German cement industry was represented by 25 exhibitors. Amongst them were the cement works of Stettin and Bonn, Mr. Adolph Kroher, of Staudach, &c., whose products compared favourably with the English cement exhibited. During the last 20 years the cement industry in Germany has been greatly stimulated, and much careful investigation has been made, resulting in the production of fine qualities. The raw material is found partly at the mouth of the larger rivers, as for instance near Emden, where the deposits are analogous to those on the Medway, and partly in the mountainous districts, especially in the Bavarian highlands, which furnish the material for the highly esteemed cement of Staudach. The cement works of Stettin employ the tertiary clay and the chalk of Rügen and Hollin, in the vicinity of Stettin. That cement from North Germany is exported to England is an illustration of the estimation in which it is held.

Amongst other exhibits Mr. Kroher shows roofing tiles of cement, some of which have been exposed for 26 years, without showing signs of deterioration. He also exhibited bricks of cement and sand, which have a remarkable degree of hardness, and are supplied at prices somewhat lower than those of common bricks.

Bricks were exhibited in Group I. by Messrs. Lürmann, Meyer, and Co., of Osnabrück. This firm employs hydraulic lime and blast furnace slag supplied by the Georgs-Marienhütte. The slag flows into a tank of water, and becomes disintegrated; it is then mixed with the cement and pressed by steam power into bricks, special presses being required, as the ordinary machines did not give sufficient solidity to the bricks.

Although the granulated slag will harden of itself on account of the silicic acid it contains, the process is accelerated by the intimate admixture of lime, the slag being ground and mixed with the former in a suitable mixing mill. At present these makers are engaged in the production of large blocks for building purposes.

The German brick industry was, in all respects, well represented. The Laubauer Brick Company made a very large exhibit, as did Messrs. E. March and Sons, of Charlottenburg. This latter firm showed a structure of their products, consisting of light yellow bricks, inlaid tiles, and glazed decorated plates. The tiles are produced as follows: On the light yellow ground drawings are made, and coloured clays are pressed into the lines. After drying the tile is surfaced, and the drawing sharpened and finished.

The principal difficulty arises from unequal shrinkage, but this has been successfully overcome by Messrs. March and Sons. In the exhibit just mentioned were some beautiful red terra-cotta columns and pilasters, and a masterpiece of terra-cotta work was a figure of Germania placed in the centre. The floor was covered with Mosaic work extremely well executed.

The Greppiner Works, formerly Mr. C. Aug. Stange, produce yearly about 6,000,000 yellow and red facing bricks, and about 3,500,000 of yellow bricks for inside work, which are very strong and light. Besides these bricks, large quantities of terra-cotta are annually produced by this firm. Various samples exhibited show a superior quality of material, and the forms are sharp.

The facing bricks and terra-cotta exhibits of the Dithmersch Brick and Clay Company may be mentioned in passing. The Clarahütte, of Hirschberg, Silesia, showed large and good clinker bricks. These works turn out large quantities of tiles and drain pipes.

There were about twenty German exhibitors of fireproof building material. The most important were Messrs. Vygen and Co., of Duisburg-upon-Rhine. They exhibited large blocks for blast furnaces of excellent material and well finished. Mr. Keller, of Stolberg, near Aix-la-Chapelle, showed refractory stones of a class much used in this district. Mr. Schenkelberger, of Saarbrücken, exhibited a very complete collection of fire-resisting material in Group I. The Silesian fire-proof industry was represented by Mr. C.

Kulmiz, of Saarau, and Messrs. Haupt and Lange, of Brieg. The first-named firm does a large trade in Prussian and Austrian Silesia, and works up 18,500 tons of clay a year. The latter make so-called Dinas bricks with quartz and gneiss. A speciality of their make is large retorts, some exhibited weighed 1½ tons.

Glazed tiles were largely and finely represented in the German section. Mr. Charles Seidel, of Dresden, showed some fine white Dutch tiles, gilded and, very brightly enamelled. The similar exhibits of Mr. Schröder, of Potsdam and of the Stone Manufacturing Company, Stettin, were very excellent, the materials, designs, and finish being all commendable.

Some antique German stones of good design were exhibited by Mr. Fleischmann and Mr. Th. Lunz, of Nürnberg, and by Mr. W. Schmidt, who have imitated the old Nürnberg and Augsburg models with great success. The large stone shown by Mr. Schmidt, of Münich, in the Rotunda, had but little merit. The tiles were covered with a dark blue but imperfect glazing, and were decorated with designs in silver. The stones of Messrs. Villeroy and Boch, of Dresden, are of excellent design. The tiles are of fire-clay, well glazed. The wall tiles shown by the same firm were also extremely good, both as regards material and workmanship. The production of these tiles by this firm amount to a value of about 1⅔ millions of thalers per annum. The manufacture of the so-called Mettlach floor tiles are a speciality of this firm. They are formed of dry powdered clay, subjected a high pressure. The patterns and colours of these tiles are good and very brilliant, the quality is uniform, and the price is such as to secure a large home and export trade. The potteries of Sinzig, in Rhenish Prussia, erected in 1870, sent good examples of floor tiles and mosaics, in which very bright colours predominate.

Turning now to the collections of materials for covering roofs, besides slates, there were 23 exhibitors showing felt, paper, wood, cements, &c. Mr. Jacob Felten, of Cologne, is one of the leading makers in this industry. Another was Mr. Ad. Irmer, of Berlin, whose works were recently destroyed by a steam boiler explosion, but which are now restored. About 1,550 tons of raw material are worked up by this maker per annum.

Zinc roofing was exhibited in the metallurgical division, as well as in the building section. In the latter were also good specimens of ornamental zinc work for ridges and roof decoration, shown by Mr. Thielemann, of Berlin, and Mr. H. Geister, also of Berlin, showed in the Rotunda a trophy consisting of a church spire in zinc, the design and execution of which were excellent. The metal is chiefly supplied from Silesia, Rhenish Prussia, and by the Vieille Montagne. This latter company showed in one of the German pavilions a variety of zinc roofing plates. They had besides a small building entirely of zinc. It was octagonal in plan, and each side showed a variation in design and construction.

Zinc plates coloured red, black, and white, in imitation of tiles, were shown taken from a roof in Münich, where they had been exposed for 27 years with a very slight loss in weight.

Austria.

The exhibits of Austria in the section under consideration, were, as may be expected, very large. We may commence as before with natural building material. Few countries are so wealthy in building stones as Austria and its dependencies. The limestone in the lower deposits of the Vienna basin is very largely quarried, and is extensively used for building purposes. The colours range between white, light grey, blue, and yellow, these tints being often blended together. The Wöllersdorf stone is distinguished by great hardness and purity of colour. The whole of the Elizabeth Bridge, and large portions of the Votiv Church, the Opera House, and the State railway stations, in Vienna, are built of this stone The quarries, formerly private properties, now belong to the Wöllersdorf Company. The quarries of Fischau, near Wöllersdorf, produce stone of a quality equal to that from the latter place. The Mühlendorf limestone is also of a similar quality, although in places it contains crystals of dolomite. This stone was also largely employed in the Votiv Church, Vienna, the towers of which are formed of it. The so-called imperial

stone from the quarries of Mr. Zeintler, in Sommerein is extremely hard in the lower beds, and has blue and yellow tints. It is much employed for staircases, balconies, slabs for landings, &c., as well as for foundations.

The Breitenbrunn stone from the neighbourhood of Neusiedeler is a fine-grained white limestone, very suitable for finished carving and statuary. It is employed in the archways, columns, and capital of the Vienna Opera House. The Margaretha sandstone, from St. Margarethen, is a fine stone, easily wrought, and employed in two qualities, one harder and denser than the other. This stone has found a large application in the restoration of the tower of St. Stephan's Cathedral in Vienna. The quarries of Brünn am Steinfeld, yield a very fine red standstone, strong and of fine appearance, but unfortunately of very variable quality, as is also that from the quarries of Baden, near Vienna. Both stones are largely employed for building in the Austrian capital. The Vienna or Karpathen sandstone is of a bluish grey colour, with a fine quartz base, cemented by lime and clay. It quickly disintegrates by exposure, and is, therefore, chiefly used for foundations. Between the layers of this stone considerable quantities of material, suitable for the manufacture is hydraulic lime, are found.

Besides stone, the Vienna basin contains large deposits of clay, which are worked up by the various brick and pottery factories around Vienna.

Other classes of stone for building purposes than those just mentioned are, however, employed in the city, as for instance that supplied by the Road and Bridge Construction Company, who exhibited an imposing selection of rough and wrought granite, including some enormous slabs, exceeded only by one or two in the German section. The worked stone, forming columns, water basins, &c., showed good workmanship. The quarries and factories of the company are situated near Mauthausen, and Neuhausen, Upper Austria, but have only been worked under existing conditions since 1872.

The Salzburg district supplied various kinds of marble to the Exhibition. The Untersberger quarries, owned by Baron Löwenstern, were represented by brown, grey, and red marble. The stone is easily worked, and very uniform in quality. Since 1864 the owner has successfully introduced machinery for working and finishing this stone into various forms, and a large quantity of small pieces, for pavement, &c., are turned out annually, finding foreign markets in Germany, Holland, and even in this country. Other quarries near Salzburg produce a stone known as "Scheck marble," largely used for building purposes.

Specimens of Hungarian marble from Comorn and Fünfkirchen, in Carinthia, were shown. In the Carinthian pavilion was an interesting collection of building stone, consisting of small cubes, the more important classes being further represented by large blocks. Amongst others was a fine white limestone found in the Kras Valley, near Villach. The largest quarries of this stone are those of Mr. Vogler and Mr. Ohrfandl, both of them supplying considerable quantities to Marburg in Styria. More commonly found than this is a marble-like stone of light blue tint with dark veins, which takes a high polish, and is of considerable beauty. It is largely used for monumental purposes. Near Pörtschach is a fine-grained white and reddish limestone, with green veins. This stone is largely quarried.

Mr. Ohrfandl, above named, exhibited, behind the Carinthian pavilion, various specimens of marble, chiefly of a dark tone, with white veins. This stone is employed for building and road metalling. A fine red and white-veined limestone, quarried on a small scale near Malborghetto, was represented. The stone exists in large quantities; but cheap means of transport do not at present exist. A beautiful and but little known marble of dark red hue is found close to Arnoldstein, and upon a line of railway. It is but very recently that these quarries have been opened.

Tufaceous limestone is met with frequently in Carinthia, especially near Greifenburg. It is easily quarried, and its lightness and strength recommend it as a building material. Sandstone is found in considerable quantities near Klagenfurt, Bleiberg, &c. The white is employed for building, and the red, containing large quantities of quartz, is largely used in the manufacture of fire-resisting material.

Although collections from other Austrian principalities were lacking, there were many individual exhibitors. Thus Messrs. Cloetta and Schwarz, of St. Croce, showed blocks of grey and black dolomite of very large dimensions, with finished and polished columns, and other examples.

From Silesia and Moravia were sent some fine collections of stone. The larger proportions of slate used in Austria come from Silesian and Moravian quarries. The Schiefenberg-bau Company, of Olmutz; Messrs. Alscher, Hand, and Co., Eckersdorf, Silesia; Messrs. Lindner Brothers, Troppau, and some other firms showed specimens of slate of dark blue colour, and a small building standing near the Styrian pavilion was roofed by green slate sent by Messrs. Johann Liebig and Co. The interior of this house was filled with a variety of slate products.

Turning to artificial building material, we may consider, first, the hydraulic limes and cements which are manufactured by a large number of Austrian firms. One of the chief producers is the Perlsmoos and Hydraulic Lime and Cement Company. The materials used in the well-known Perlsmooser Portland cement are found in great quantities near Häring, about two miles from Kufstein, in the Lengau Valley. About 30,000 tons are annually worked up into hydraulic lime and cement. The company exhibited a complete series of its products in an open building behind the Imperial pavilion. The roof was carried by monolithic columns of cement, and the floor was covered with Mosaic cement tiles, the colours and designs of which were excellent. It was noticeable, however, that this application of the material showed imperfect powers of resistance to the action of the weather.

Messrs. Carl Lissbauer and Co., of Vienna, also exhibited a pavilion of cement, and containing many specimens of the different applications of their materials, including some artistic productions. This firm manufacture about 50,000 tons of cement and hydraulic lime, and 12,500 tons of gypsum per annum. In the neighbourhood of Steinbrück, Styria, is a dark-blue limestone and argillaceous marl-slate, which have been successfully employed in the production of hydraulic cement for the past 14 years by the "Steinbrücken Cement Fabrik." The stone is burnt in five continuous furnaces close to the quarries, and then reduced in a crushing mill.

Mr. Julien Chailly, of Vienna, manufactures building blocks by mixing cement and broken stone. In illustration of his products, he exhibited a small monolithic house, which so far has resisted well the action of the weather. The principal application of Mr. Chailly's process, which was previously followed at Stuttgart, are for foundations, basements of houses, flooring, railway station platforms, steps, slabs, &c. Almost all the railway companies at Vienna have largely employed them. Besides these, the Oesterrische Allgemeine Baugesellschaft, the Wiener Baugesellschaft, and the Baugesellschaft zur Herstellung billiger Wohnungen (the Cheap Dwelling House Company) use Mr. Chailly's material.

Mr. H. Escher, of St. Andrea near St. Rovigno, manufactures a good cement in large quantities, which is also worked up into bricks. This maker exhibited a large pillar formed of such bricks and mouldings, the latter showing many cracks. A greater power of resistance is claimed for this than the English Portland cement possesses.

Amongst a series of other cement products, we may call attention to a small but important collection shown by the Wiener-Weiss cement Actien Gesellschaft. This company, whose works are situated in Mödling, employs dolomitic lime.

Turning to the consideration of bricks, terra cotta, &c., we find, as may have been expected, a large number of exhibits. The largest brick factory of the empire is that of the "Wiener-burger Ziegelfabricks und Bau Gesellschaft. Collectively the Austrian factories produced in 1870 about 1,000,000,000 bricks of different kinds, and of this quantity the above-named firm supplied 120,000,000. That year showed an increase in the produce of 1872 by 47,000,000. The company exhibited specimens of all its products, which were noteably collected in a large arch to the east of the Kunst-Halle in the Exhibition grounds. This structure was a masterpiece of design, and the

excellence and variety of the materials employed made it one of the striking objects of attraction.

In consequence of their acknowledged excellence, the Wienerberger bricks are almost exclusively specified for state and municipal buildings. The numerous tunnels on the Northern railway, the stations and buildings of the Semmering line, the conduits and aqueducts of the Vienna waterworks, recently finished, are all built with the bricks supplied by this company. Owing to the extent of their works it will be seen that the company takes the leading position in the brick industry of Austria, and without its aid the Exhibition buildings would scarcely have been completed in time. Besides bricks, the Wienerburg Company, produce a large quantity of tile of different kinds, as well as terra-cotta. Both kinds are equally well known for the art displayed in modelling, and for the large size of the pieces produced, as was illustrated by the gigantic trophy at the archway above mentioned. Of late years the company has made a specialty in the production of glazed terra-cotta medallions, for architectural decorations. A well known chemist, M. F. Kosch, formerly connected with the Imperial porcelain factory of Vienna, deserves, we believe, the credit of this product. The principal advantage is that the numerous colors employed, are fixed with one baking. The glaze is entirely free from cracks, and is very durable and cheap. The company has recently extended its works to meet the demand which has sprung up for these medallions, tiles, &c. In conclusion we may mention that the Wienerburg works find employment for 8,000 men.

We may in passing allude to the Laaerberg and the Rothneuzeigel works, both large brick factories, and in the latter of which machine bricks were first made at Vienna.

The oldest terra-cotta works in Austria are those belonging to M. Victor Krausewetter, of Wagram, near Lakersdorf. They were established in 1839 by Baron Dacklhaff, but the first practical experiments in producing burnt clay decoration for architecteral purposes were made in 1842. Mr. Krausewetter exhibited a number of artistic groups of excellent colour, and a large and well executed fountain also of terra cotta. It may be mentioned that very high prices appeared to distinguish the exhibits of this maker.

M. de Centre, of Wiener-Neustadt, whose speciality appears to lie in the production of stoves, had some exhibits worth a passing glance, and the few remaining exhibitors of this industry, may be grouped together and passed without criticism.

There were but comparatively few and insignificant exhibits of fire-resisting material in the Austrian section, although the country is very rich in such materials. The geological "Reichaustalt" alone showed a collection of 82 refractory clays, and this collection was far from being complete. One of the best deposits of refractory clay is found near Blankso, in Moravia, and it was amongst the first worked successfully in the country. It is distinguished for its white colour, which its retains after having been burnt. The price, however, is very high.

M. de Centre, of Wiener-Neustadt, has attempted to produce Dinas-stone from the quartzite found in his locality, but he has hitherto failed, and his productions are decidedly inferior.

Bohemia possesses a great wealth in suitable materials, but which as yet is but little developed, and the same is the case with Hungary, demands being met by importation.

The show of glazed clay products was limited to tiles, many of which were decidedly inferior. Even M. de Centre, one of the largest makers of these tiles, exhibited quite imperfect specimens, the designs of which were also inferior. M. Sommerschuh, of Prague, formed, however, an exception to the general rule.

In finishing the review of Austrian exhibits of building materials, we finish all that need be said upon the subject. The few scattered and imperfect contributions from those countries which we have not included, need not find a place in such a report as the present.

IRON AND STEEL.

It is a well-known fact that the progress of our various branches of industry during the last twenty years has been characterised by a constant increase in the quantities and dimensions of the manufactured products. The consequences of this fact can be followed in every branch of our industrial enterprises; in the manufacture of paper, cotton, wool, and similar articles, as well as in the construction of all varieties of power engines, machines, tools, ships, docks, and public works. In no branch of industry, however, do we find this growth so prominent as in connexion with our metallurgical processes.

Every new exhibition proves the correctness of this statement, and shows us vastly enlarged dimensions of cast iron, steel and wrought iron products, as well as a steady increase in volume of the quantities dealt with in the different smelting processes. The progress which has been made since the first Exhibition in 1851 in the manufacture of steel and wrought iron is well known, and we need not infringe on the time of our readers by an enumeration of our various new methods which have been brought forward for the production of steel and iron on a large scale. Nevertheless the Vienna Exhibition showed in connection with its display of iron products, certain historical features which may prove of interest to the ironmasters in this country so much the more as the study of our most recent progress in the iron and steel manufacture has proved the latter to be in most cases merely an application of old and well-known principles to large masses.

We believe, in consequence, that a brief historical record of the development of metallurgical processes will not only be interesting to the reader, but often may help us to solve questions of great importance, and to give our ideas a fresh and remunerative impulse; and we propose therefore in the following report to speak not merely of the exhibits at Vienna, but to give some historical facts and statistics relating to the countries by which they were contributed. We shall in the first place deal with pig iron and its production and proceed on subsequently to treat of the production of castings and the manufacture of welded iron and steel.

Pig Iron and its Manufacture.

All political economists appear now-a-days agreed that, next to coal, there is not one of nature's gifts of such paramount importance for the industrial and political power of modern nations as iron, and the quantity of its production offers a fair standard for their wealth and importance. The total production of the globe with regard to pig iron and malleable iron made direct from the ore, is estimated at 15,322,500 tons per annum approximately, and it is divided amongst the different countries as follows in round figures :—

	Tons.
England	6,733,000
United States	2,800,000
Germany	2,664,000
France	1,182,000
Belgium	565,000
Austria-Hungary	425,000
Russia	360,000
Sweden and Norway	306,000
Italy	74,000
Spain	72,000
Switzerland	7,500
British and South America	50,000
Japan	9,000
Asia	40,000
Africa	25,000
Australia	10,000

These figures show at a glance the enormous preponderance of England, North America, and Germany over all other countries with respect to their capability of producing iron, as they alone make two-thirds of the whole quantity, which, as it seems, is still not enough to respond to all demands.

We commence our present review with the United States of America, which rank second in the list of iron-producing countries, and can boast of a growth of their iron industry equalled by no other nation. We follow the Potsville coal statistical register in demonstrating that fact by the following figures. The produce of pig iron in the United States was in

	Tons.
1810	30,000
1830	165,000
1840	345,000
1850	600,000
1860	913,700
1864	947,600
1865	931,582
1866	1,350,343
1867	1,461,626
1868	1,603,000
1869	1,916,641
1870	1,865,000
1871	1,912,608
1872	2,830,000

These figures show that in 62 years the production has increased 96 times as compared with 1810, and under these circumstances a few words on the history of the development of the North American iron trade will not be out of place here.

When, in the early part of the 17th century, our colonists settled on the Atlantic seaboard of North America, they seem to have got what little iron they wanted from the mother country, and only after some lapse of time did they begin to make malleable iron direct from rich and pure ironstones in so-called ore bloomeries and low wolf-furnaces. When treated by either of these processes ores which could be easily reduced to the metallic state in a charcoal fire, such as carbonate or spathic iron ore or brown manganiferous hematite, yielded a lump of metal, called a pig or wolf (loup in Walloon countries), still rather impure and mixed with slag, but which, when re-heated and hammered properly, yielded an excellent kind of tough wrought iron. Charcoal blast furnaces seem to have been first erected in the early part of the 18th century in the New England States, where rich iron ore and large forests were at hand, and they followed westward in the wake of the ever-advancing pioneers as soon as iron had become a necessary of life in the new settlements. With the destruction of the forests these iron works also closed their career, and charcoal blast furnaces are at present only left in the New England States, New York, New Jersey, Pennsylvania, Maryland, as well as in Michigan, Alabama, and Tennessee, these furnaces having, in 1871, made 387,000 tons of pig iron altogether. That their number was very restricted up to the year 1830 may be inferred from the annual production of only 30,000 tons in 1810, and 165,000 tons in 1830. After the use of anthracite coal or culm in blast furnaces had been successfully introduced in South Wales by Mr. Crane and Mr. Budd about the year 1836, it was carried over the ocean by a Welshman named David Thomas, who in 1837 started the first anthracite blast furnace in America at Manch Chunk in the Lehigh Valley in Pennsylvania, where there are now over 40 furnaces in existence. The employment of anthracite as fuel for iron making spread gradually to the valleys of the Schuylkill, the Upper and Lower Susquehanna, the Juniata, and to the eastern and northern districts of Pennsylvania, where, in 1871, not less than 873,000 tons of anthracite pig were produced by about 73 furnaces. The iron industry had meanwhile passed over the Alleghanies and in western Pennsylvania, in Clanin County, and in Ohio, at Youngstown and Zanesville, it found at its disposal beds of the so-called block coal, which breaks into large lumps, is hard, free from sulphur, rather dry, and admirably

suited for blast furnace fuel in the raw state, just as are the similar coals of South Wales and Scotland. Numerous new furnaces were here erected and fed partly with native ironstone, partly with rich magnetic iron ore from Lake Superior, and at Pittsburg their number increased in a single year from 5 to 12, with a weekly produce of 3,600 tons. From thence the furnaces spread north and north-west to Lake Erie, to Cleveland in Ohio, Mahoming, Stenango, and other places, and already in 1860 no less than 76 blast furnaces and 24 forge mills existed in Ohio, Indiana, Michigan, Illinois, Wisconsin, and Kentucky, amongst which were five at Brazil, in Indiana, one at Terre Haute, and 15 at St. Louis. The latter furnaces were supplied with ore from the iron mountain in Missouri, which in 1868 yielded 105,000 tons, in 1869, 195,000 tons, in 1870, 316,000 tons, and in 1871, 500,000 tons of rich red hematite iron ore. Almost all the other furnaces of Ohio and Indiana receive vast quantities of magnetic iron ore from 16 mines of the Lake Superior district, which, in 1856, only yielded 5,000 tons, in 1860, 116,900 tons, and in 1870, 856,470 tons of ore, besides 50,000 tons of pig iron made in the district. Alabama promises also to produce large quantities of rich brown and red iron ore in Falladega, Bibb, Shelley, and Cherokee counties, as well as oolithic red iron ore with 50 per cent. of iron from the Red Mountain, between Gadsden and Tuscaloosa, which is estimated to contain over 20 milliards of tons. The number of blast furnaces in the United States was, in 1872, 545, and in 1873, 641, of which number 83 were quite recently built.

Besides these blast furnaces there are still at work numerous ore bloomeries—a kind of Catalonian forge—which make iron direct from the ore, particularly so in the states of New Jersey and New York. Amongst the United States iron exhibits at Vienna we met with a bloom from such a bloomery, shown by the Clifton Mining Company of St. Laurent, in New York, this bloom having been made from magnetic iron ore belonging to the Laurentian or azoic period; the same company exhibited likewise charcoal pig iron of very good quality. Similar iron ores and iron were produced by the J. and J. Rogers Iron Company, of Ausable Forks, New York, by C. S. Johnston, of New York, and by Witherby, Sherman & Co., of Port Henry, New York.

From Indiana we found samples of ironstone and iron by the state geologist, Mr. E. D. Cox, and a very good exhibition was made by the Brazil Furnaces, of Brazil, Clay County, Indiana, including six kinds of pig iron made with raw block coal, number one being dark grey, number two middle grey, number five mottled, and number six white pig. The Muddy Iron Company, of St. Louis, Missouri, showed pig iron, and John M. Krum, and the Ravold Iron Company, of St. Louis, iron ore, while Mendenhall and Kitchell, of Cincinnati, Ohio, brought forward good specimens of pig and wrought iron. The Irondale Company, of Jefferson, Alabama, was represented by brown iron ore and red oolithic hematite of the Devonian age, containing numerous shells of the genus Spirifer, whilst they also showed samples of grey and white pig iron made from these ores with charcoal as fuel. Their blast furnaces are 58 ft. high, 7 ft. diameter at the top, and in the boshes 12 ft., as are the furnaces of the Jefferson Iron Company, near Birmingham, and of the Red Mountain Iron Company, at Ironton, Alabama, which smelt the red ore mixed with black band from the coal measures of the Warrior coalfields. Richard Rothwell also exhibited iron ore from Alabama, and E. B. Ward, of Detroit, Michigan, magnetic, brown, and oolithic ore. Of particular interest was the collection of George R. Tuttle, of Cleveland, Ohio, which embraced fine specimens of specular iron ore, magnetic ore, and hematite, from the principal mines in Marquette County, Michigan, which produce the famous Lake Superior ore. The Dunbar Iron Company, of Pennsylvania, exhibited samples of clay iron ore or sphærosiderite, limestone; fire-clay, and three kinds of grey pig, made with coke from clayband, which produces a lavender blue slag. Lastly the collection of the North Pacific Railway Company included also specimens of fine brown hematite, and of charcoal pig iron from Oregon.

From South America we noticed samples of red specular iron ore from Baruta and Petare, near Caracas, in the State of Venezuela, while in the Department of Brazil was an iron exhibition by Dr. Souza Mursa, comprising

the products of the iron works at San João de Ipanáma, province of Santo Paulo. Here from red hematite and magnetic iron ore, with an addition of limestone, charcoal pig is made and refined in open forges or bloomeries with blast, when the bloom is cut in two parts, and rather roughly hammered out into bars.

The departments of Great Britain and her colonies were very indifferently represented, considering that this country is the greatest iron producer. A few interesting exhibits, however, were to be found, amongst which we may mention a collection of grey and white pig iron, made with coke fuel at the works of the venerable Bowling Iron Company, near Bradford, in Yorkshire, and which serves as an excellent raw material for the production of cast steel at some of the Sheffield works. The Bowling Iron Works were founded in 1784, and the first blast furnace was blown in here in 1788, while at the sister works of Lowmoor, this happened in 1791. The first furnaces had only one tuyere in the back wall, but they were soon provided with two, one in each side wall, and worked with blast of a pressure of only 2 lb. per square inch, and with nozzles 2¾ in. diameter. It is of no mean historical interest that the Bradford district produced iron even in the time of the Romans, as is proved by the discovery of large heaps of iron slags at Bierley, about two to three miles from Bradford, which heaps enclosed coins of Roman origin. The neighbourhood of Bradford, however, was not the sole Roman iron district, as similar slags are found upon the hills of Somerset, and in very large quantities in the Forest of Dean in connexion with Roman altars, dedicated to Mars, the god of iron and battle. These slags are still so rich, containing 30 to 40 per cent. of iron, that it has been deemed profitable to re-smelt them, and during three centuries about 20 small charcoal blast furnaces existed in the Forest of Dean, and were fed by these Roman slags. It is, however, unquestionable that iron was made by the ancient Britons even before the Roman conquest, as Cæsar found them to possess iron weapons and implements at his first invasion. It is rather remarkable, that Roman iron slags are always found on the tops of hills, and never in a valley, where water power could possibly have been utilised, from which it seems, that the Romans did not employ bellows, but used the natural draught of the wind in so-called air bloomeries. These were hollows dug out at the top of a hill with covered channels, leading to the hillside in the direction of the prevailing wind, which would blow through them into the fire, the latter being kept up with wood or charcoal, and iron ore being introduced into the burning mass. It is evident that this process was very rough, and attended with great losses of iron, which was left in the slag. Similar air furnaces, however, were in use for the smelting of lead in Derbyshire as late as the seventeenth century. As soon as bellows were introduced, about the eighth century, the smelting places became more independent, and were removed to the valleys, when so-called blast bloomeries came into use, these having built up walls, which were gradually heightened to about 5 ft. or 6 ft., with a diameter of 3 ft. to 4 ft., and thus became wolf furnaces, which were employed in America and Hungary until less than 100 years ago, and are still in use at this day in Turkey and India. These furnaces were at first rectangular, but after the 16th century they were made of an elliptical, and in the 18th of a circular section. They, however, were not in a condition to produce a fusible cast iron, as they only could deliver lumps, "wolves," or pigs of half malleable wrought iron.

The next step in the perfection of iron smelting was the invention of small blast furnaces or blow furnaces about the end of the 13th century in the countries bordering the left side of the Rhine and in Belgium, and in 1377 cast-iron guns were made already near Erfurt in Thuringia. From the Rhine the blast furnaces were introduced to England. In the Forest of Dean these early charcoal blast furnaces, 15 feet high and 6 feet wide at the boshes, came into existence about the beginning of the 16th century, and David Mushet found there two of them left, these having probably been built about 1550, during the reign of Edward IV. It is certain that at the time of Queen Elizabeth, the art of iron casting had attained a certain degree of perfection, as cast-iron ordnance were then largely exported to the Continent, and the annual

production was estimated at 180,000 tons of charcoal pig iron. The reckless devastation of the forests, however, caused a great scarcity of charcoal, and three-quarters of all blast furnaces had come to a standstill in 1730, when the total produce of pig iron had sunk to a little over 17,000 tons. As the total extinction of the British iron industry seemed unavoidable, efforts were made to replace the charcoal by mineral fuel, and James I. granted several patents for its use in blast furnaces. Already in 1612 Simon Surtevant, and in 1613 Ravenson tried it without success; Lord Dudley, however, who obtained in 1621 a patent for the "misterie and the arte of melting iron ewre " with sea coles or pit coles in furnaces with bellowes," seems really to have made at Dudley three tons of pig iron from a furnace in a week with coal or coke. Raw coal, and perhaps coke, appear to have been mixed with charcoal in many furnaces during the latter half of the 17th century, but it is certain that coke alone was used by Abraham Darby in the furnace of Colebrook Dale, in Shropshire, between the years 1730 and 1735. Darby, after many efforts, had at last succeeded in making coke from coal by charring it, like wood in a pile, and by its use he obtained coke pig iron about 1735, his greatest difficulty being to get blast of sufficient pressure to consume the dense coke with ease. The next coke blast furnaces were put up by him at Horsehay, near Colebrook Dale, and he obtained from them, in 1756, 20 to 22 tons of pig iron weekly. Only the introduction of more powerful blowing machinery, when Smeaton in 1760 erected the first cylinder blowing engine at the Carron Works, in Scotland, was able to increase the yield of the blast furnaces by burning a quantity of coke, which the bellows could not consume. At this time coke blast furnaces were introduced in Scotland, where at the Carron Iron Works, near Falkirk, the first was blown in in 1760, by Dr. Roebuck, of Glasgow, and in 1792 their number had increased at these works to five. Next came the Wilsontown Works in Upper Lanarkshire, erected in 1780 and 1781 by the Brothers Wilson, and it was here that John Condie, the inventor of the spiral water tuyere, was also the first to use raw splint coal as fuel in the blast furnace. The Omoa Iron Works in Lanarkshire and the Muirkirk Works in Ayrshire were started in 1787, the Clyde Iron Works, near Glasgow in 1788, and it was here that David Mushet began his professional career, and that James Beaumont Neilson was successful in employing hot blast about the year 1828. In 1792 the Devon Iron Works at Clackmannan, north of the Forth, were started, and here were the first, though unsuccessful, attempts made by Alexander Christie to utilise the waste gases from the furnace. Next followed the Calder Works in 1801, Shott's Works, 1802, Monkland, 1825, Gartsherrie, 1830, Dundyvan, 1833, Coltness, 1836, Summerlee, 1837, Langloan, 1841, and several others after the expiration of the hot blast patent; amongst these were the Almond Iron Works in Linlithgowshire with a furnace 72 feet high, which was once the highest in Scotland, and was only surpassed recently by Mr. W. Ferrie's self-coking blast furnaces at Calderbank. At Calder Works the first black band ironstone, which had been discovered in the coal measures by David Mushet, was smelted by him and W. Dixon, and the prosperous owner of Gartsherrie, Mr. John Baird, who had been managing partner for 40 years at the Shotts Iron Works. We thus see Scotland took the lead in the development of the British iron industry at the beginning of our century. Her annual production of pig iron was in

1820	20,000 tons	from 16	furnaces.
1839	197,000 „	39	„
1845	475,000 „	88	„
1850	630,000 „	105	„
1855	825,000 „	122	„
1860	1,000,000 „	133	„
1865	1,640,000 „	136	„
1870	1,206,000 „	126	„
1873	993,000 „	119	„

and her number of coke blast furnaces gradually increased from one in 1760 to 10 in 1800, 26 in 1825, 120 in 1850, and decreased again to 171 in 1860,

163 in 1865, 160 in 1870, and to 152 in 1873, the fact being that during the last 10 years a number of smaller furnaces have been pulled down and replaced by others of larger construction.

After this historical digression we must return to the iron exhibits at the Vienna Exbibition, and we have next to notice some samples of dark gray Bessemer pig iron, made from red hematite at the Hematite Iron Works, Moss Bay, Workington, Cumberland, and which, according to an analysis by T. W. Montgomery of Whitehaven, contains

Graphite	3·303
Silicium	1·309
Sulphur	0·016
Phosphorus	0·006
Manganese	0·720

This composition shows an excellent quality for the production of Bessemer steel, in fact the grey pig iron, made from Cumberland and Lancashire red hematite has become of such importance for all Bessemer steel works, that it is now almost exclusively used and preferred to all other sorts of British pig iron. We have here another instance of rapid industrial development. While the use of this hematite of the north not long ago was restricted to a few charcoal blast furnaces, of which we saw in 1854, the last in blast at Newland near Ulverston, and while it had even been tried at Bonaw or Lorn in Argyleshire with doubtful success as long ago as 1763, it only came gradually into use in the blast furnaces of Yorkshire, Staffordshire, and even South Wales, when the connexion with the district by railways was established. This fine iron ore, with 60 to 65 per cent. of metal, and almost free from sulphur and phosphorus, is found embedded in the mountain limestone of North Lancashire, Westmoreland, and Cumberland, and forms irregular beds sometimes 20 and 30 feet thick. It was of course a welcome material to the ironmasters of the southern districts, who found increasing difficulties in supplying their furnaces with good and rich ore. Thus it came about that the district of Furness, which in 1800 only yielded 1,200 tons of ore, had in 1849 increased its production to 182,000 tons from 17 mines, of which quantity all, with the exception of 3,000 tons, were exported, while now the great works of the Furness district at Barrow and of Workington, in Cumberland alone consume double as much ore as was raised 25 years ago. In fact these works have since that time become models of economical and scientific iron smelting, and as they consume the greater portion of the annual out-take of iron producing material, the other districts have been obliged to look out for new sources of rich ore. It seems that the mines near Bilboa in Spain, and those of the county of Antrim in Ireland, which have increased their output from 50,000 tons in 1859 to 200,000 tons in 1873, will be greatly called upon to make up for the deficiency.

From the Cleveland district, which has become the rival of Scotland for quantity though not for quality of product, we found shown at Vienna models of one of the most important additions to blast-furnace plant which has been made of late years, namely, Mr. Thomas Whitwell's hot blast stoves, which allow blast to be heated almost to a red heat, a temperature hitherto unattainable in regular working, and which permit Neilson's invention to be utilised to a degree that had hardly been dreamt of before. The principle of Siemens' heat regenerators for reverberatory furnaces and of E. A. Cowper's hot blast stoves, is applied in Whitwell's invention, but in a modified form, the chambers filled with open laid bricks which form the Siemens' regenerators being replaced by a number of narrow brick chambers, through which the burning waste gases of the blast furnaces and the cold blast are passed alternately and in contrary directions, the burning gases heating the chambers, and the cold blast when subsequently conducted through them on its way from the blowing engines to the furnace, absorbing from the walls of the chambers the heat previously imparted to them. This arrangement allows of the perfect cleaning of the chambers in a few hours without entailing the necessity of cooling them down previously, as in other hot blast stoves; and as

the heating material is firebrick, the blast can easily be brought to over 1,400 deg. Fahr.

The illustrations, which we give on Plate XXV., Figs. 1 and 2 will explain the construction of Mr. Whitwell's stoves more clearly. Fig. 1 on that Plate represents a stove adapted for heating 3,000 cubic feet of blast per minute. In this stove the gas for heating is admitted by the pipe B, and enters the stove through an argand burner having an annular and central jet, as represented in the section, which also shows the branches through which the jets receives the necessary supply of air. The air admitted to the gas on entering is not sufficient to produce perfect combustion, the latter being completed by admitting a further supply of air to the gas at different points during its course through the flues. This secondary supply of air is admitted through perforations communicating with air flues built in the division walls, the effect of this arrangement being that the heat is more equally diffused throughout the whole of the stove than it otherwise would be, and a very intense heat at any one point is avoided. The perforations in the air flues are, of course, on one side only, or otherwise the blast, when it is traversing the stove, would pass through the walls instead of under and over them. In our engraving only two of the secondary air ways are shown.

The heating gases, after traversing the stove and passing alternately over and under the division walls, are led off through the flue D, to the chimney, the mouth of this flue, like that of the inlet flue B, being furnished with a valve by which it can be closed; these valves are shown raised in the section. When the stove has been sufficiently heated the combustion gases are shut off, and the blast admitted at C, close to the gas outlet, from which point it is made to traverse the stove to the pipe A, which conducts it to the blast furnace. The pipes A and C, are fittted with valves.

The duration of each "turn" or the times during which each stove is being heated by the gases, or cooled by the blast, may vary slightly; but at the Consett Works, where four of these stoves are worked in connection with one of the blast furnaces, the time is usually about two hours, the stoves being changed in pairs. The stoves may, however, be changed, one at the time, each hour, if preferred, so as to check any irregularity in the temperature, care being taken, however, that two are always "in blast" at once.

For clearing the stoves two sets of cleaning valves E and F, are provided, one set communicating with the tops and the other with the bottoms of the flues. In ordinary working a stove is cleaned every three months, and this operation is performed without entering the stove and without its being necessary that the latter should be at all cooled down. Fig. 2 on Plate XXV. represent's the arrangment of four of these stoves at the Consett Works where they have given most admirable results.

One of the most essential details in the Whitwell apparatus is the valves, which alternately admit or shut off the gases or the blast, and therefore must fit gas-tight, as an explosion would be unavoidable if both were to mix in the stove. This valve arrangement is illustrated by Figs. 3 and 4 on Plate XXV. Hollow valves, arranged so that water could circulate through them, were tried many years ago; but they failed in practice from the bottoms of the valves being made convex upwards; the mud deposited within the valve being thus thrown down around its periphery immediately over the portion fitting on the valve seat. In Mr. Whitwell's valves, on the other hand, the bottom is made convex downwards, while, the valve is made to enter its seat instead of fitting against the outer edge or surface of the latter. Thus it will be seen from the engravings that R is a circular wrought-iron casing, with a firebrick lining, containing the valve B, and its seat. The upper part of this casing is closed with a metal cover, A. Rivetted to the inside of the casing is an angle-iron ring C, faced on the upper side, and set perfectly level. Bolted to this ring with a faced joint is a circular false seat D, this false seat being recessed, so as to carry the water seat E, with an air-tight faced joint, *a*, and having a pipe cast in and fitted with tube connexions and couplings, *b*, *b*.

The valve B, is cast hollow, the sides being connected by means of stays *c*, *c*, cast in one piece with it, and that part of the valve where it rests upon

the seat being faced and ground into the latter. To the valve B is connected the spindle L, which is turned throughout its length, and the upper end of which is closed by means of a plug *d*, through which the water tube *e*, *e*, rises. This tube is connected by a flexible coupling *f*, or in other convenient way to the water supply, and the tube passes down the interior of the spindle L, to the valve B, which it supplies with water. The spindle L, passes air-tight through the guide K, which is bored to fit the spindle; the use of this guide being to keep the valve B, and spindle L, true to the centre of the seat E.

The spindle L, and valve B, are counterbalanced by a metal weight W, of proper size, and connected to them by a chain *g*, passing over a sheave H, carried by the standard G, which is bolted to the cover A. Attached to the chain *g*, carrying the counterbalance W, is a rack M, which is actuated by a pinion carried by a bracket N, fastened to the casing R, for the purpose of raising or lowering the valve B. The water required for protecting the valve B, is conveyed from the supply pipe O, by the pipe *h*, and the flexible connexion *f*, and the pipe *e*, *e*, to the valve; it is returned by the annular space between the pipe *e*, *e*, and the inside of the spindle L, and thence by means of the flexible or other connexion *i*, to the pipe *k*, which pipe carries the water by the couplings *b*, *b*, to the pipe cast in the interior of the seat E. From the valve seat, the water is returned by the connexions *l* and *m*, to the waste water-pipe P. The valve B, may be protected from the action of high temperature by a covering of brick or other refractory material fixed by any suitable means on the exposed side of the valve.

For the regular working of a blast furnace at least three, or still better four, Whitwell stoves are used, and these for a furnace, having a daily production of 50 tons of pig iron require a diameter of 22 ft. and a height of 26 ft. These dimensions make them rather expensive, as one stove with all fittings is stated to cost about 1,200*l.*, or the full complement for one large blast furnace about 4,800*l.* The first stove on Mr. Whitwell's plan was put to work at the Thornaby Iron Works, near Stockton-on-Tees, early in 1867, and subsequently his system was more extensively tested at the Consett Works with most satisfactory results. At the Vienna Exhibition was a collection of pig iron made at the Teesbridge Works in furnaces worked with Whitwell's stoves, the collection comprising samples from dark grey to white pig iron. There were in the summer of 1873 over 160 Whitwell stoves, partly working, partly building, in England, France, Belgium, and Germany, and, no doubt, their number will still rapidly increase.

The Cleveland district, which before 1853 owned only three blast furnaces, namely, those at Witton Park, which, in 1847, made about 150 tons of forge pig in a week, had in 1873 not less than 132 in blast, thus showing the wonderful growth of an industry which 20 years ago was quite insignificant in the district. It was about 1850 that Mr. John Vaughan, who, with his partner, Mr. Bolckow, owned a rolling mill at Middlesbrough for the utilisation of scrap iron, made the discovery of the commercial value of the now celebrated layer of oolithic ironstone, which is imbedded in the lias near Middlesbrough, and which with a thickness of 14 ft., covers an extensive area of ground. The ore consists of a mixture of a grey carbonate and a green hydro-silicate of iron, with about 29 to 30 per cent. of metal; after calcination, however, by which water and carbonic acid are expelled, the yield is raised to about 40 per cent. of iron, while the rest consists of 8 to 10 per cent. of alumina, about as much silica, a little sulphur, and always a good deal of phosphorus. The principal mines are now on the western outcrop of the liassic basin, near Eston, between Redcar and Middlesbrough, and on the eastern outcrop near Guisborough. The three first furnaces of Messrs. Bolckow and Vaughan were started in 1851, they being only 42 ft. high and 15 ft. wide at the boshes, but their number increased so rapidly that in 1860 the same firm owned 16 furnaces, making 20 to 26 tons of pig iron per day with blast of 320 to 350 deg. Cels., or 600 to 860 deg. Fahr., and a consumption of 32 to 40 cwt. of hard Durham coke per ton of pig. Since then the Cleveland furnaces have been increased in size, and in 1870 Messrs. Cochrane and Co. altered two furnaces at the Ormesby Works, making them 90 ft. high, by

30 ft. in diameter at the boshes, the capacity being 41,149 cubic feet. Thus the volume of the furnaces increased from about 4,600 cubic feet in 1851 to 12,000 cubic feet in 1863, and to over 40,000 in 1870, but the capacity last mentioned is exceptional, and the more recently erected furnaces in the Cleveland district are most of them of between 25,000 and 30,000 cubic feet capacity. How enormously the production of Cleveland pig has increased the following figures show. Being about 30,000 tons before 1853, it was 1,149,000 tons in 1867, 1,695,377 tons in 1870, and 1,999,491 tons in 1873, or one million of tons more than the produce of Scotland in the same year. Thus Mr. Bolckow's discovery became of as great importance to the development of the British iron industry, as the discovery of the blackband in Scotland and Wales, the invention of the hot blast by Wilson, and the utilisation of the anthracite fuel in South Wales, which fuel was successfully introduced by Mr. Crane, at Ynyscedwyn, in 1836, and by Mr. Budd at Ystalyfera in 1842.

We cannot leave the British department without saying a word about the highly interesting exhibition of Mr. C. W. Siemens, from the Landore Steel Works, near Swansea, in South Wales. Though, strictly speaking, they embraced no sample of pig iron, they still gave a striking illustration of a new mode of making malleable iron direct from the ore, without the use of a blast furnace. We have seen in our foregoing sketch, that the direct process was the oldest employed in this country, both by Romans and Britons, and it is rather curious to notice how often of late thinking men have attempted to return to the direct method of reduction, omitting the now intervening blast furnace process. Thus metallic iron was obtained by direct reduction from the iron ore by Mr. Clay, in 1840, in a reverberatory furnace; about 1854 by M. Chenot, in Belgium; while Dr. Gurlt, about 1856, in Germany and Spain, heated and reduced iron ores in a kind of kiln by the direct action of burning carbonaceous gases which were prepared for that purpose in gas generators, and, with a certain admixture of air, passed through the ore. In all these cases the practicable feasibility of the process with rich and pure ores was demonstrated, though in none could it be called a financial success. Whether the new Siemens process, which employs direct heating gases and an admixture of carbonaceous matter for the reduction of the ore in a rotating furnace, will turn out more advantageous in this respect, remains to be seen. It seems that the samples of malleable iron, which were shown at Vienna, were only produced from exceptionally rich and pure ores, such as Spanish Bilboa hematite, or Algerian Mokta magnetic iron ore. We have some doubts whether the reduction of ordinary British ores will prove economical in the rotating furnace, and we are also inclined to believe Mr. Siemens somewhat sanguine, when he hopes to eliminate by his process the injurious effects of sulphur and phosphorus with greater success than is done by the ordinary methods. It must, however, be admitted that the phosphorus of the ore will be less readily reduced by this process than in a blast furnace.

Mr. Siemens has been engaged in the development of a process for the manufacture of iron and steel direct from iron ore since 1866, and in the pursuit of this object, he, in the year 1868, constructed at Landore a rotative furnace for the reduction of iron ore into sponge, this furnace being attached to an open hearth steel-melting furnace, where the reduced material was converted into steel by its fusion in a bath of cast-iron. According to his later plans, however, represented by a model at Vienna, Mr. Siemens effects the whole operation in the rotative furnace itself.

Referring to Plate XXVI., and to Fig. 5, Plate XXV., it will be seen that Mr. Siemens's rotary furnace consists of a set of four regenerators of the usual construction, with reversing valves and gas producers, the body of the furnace being constructed of iron, and resting upon four anti-friction rollers. Wheel gearing is applied, by which either a very slow rotative velocity of from four to five revolutions per hour can be imparted to the chamber, or a more rapid velocity of about 60 or 80 revolutions per hour.

The chamber is about 7 ft. 6 in. in diameter, and 9 ft. long, and is provided with a bauxite lining about 7 in. thick. This bauxite, which is a mineral

from Baux, in France, consisting chiefly of alumina, and capable of resisting the high degree of heat requisite for the precipitation of the iron, and at the same time of resisting the chemical action—was brought before Mr. Siemens' notice by M. le Chatelier, the well-known French engineer, some years ago. A series of experiments to form solid lumps by using different binding materials, have shown that 3 per cent. of argillaceous clay suffice to bind the bauxite powder previously calcined. To this mixture about 6 per cent. of plumbago powder is added, which renders the mass practically infusible, because it reduces the peroxide of iron contained in the bauxite to the metallic state. When the lining is completed the interior of the bricks is preserved against oxidation by fluid cinder, added to bind them together, which prevents contact with the flame. A bauxite lining of this description resists both the heat and fluid cinder in a very remarkable degree, as has been proved by lining a rotative furnace at the Sample Steel Works at Birmingham, partly with bauxite and partly by carefully-selected plumbago bricks. After a fortnight's working the brick lining was reduced from 6 in. to less than $\frac{1}{2}$ in., whereas the bauxite lining was still 5 in. thick, and perfectly compact. It is also important to observe that the bauxite, when exposed to intense heats, is converted into a solid mass of emery of such extreme hardness that it can hardly be touched by steel tools, and is capable of resisting mechanical as well as the calorific and chemical actions to which it is exposed. The bauxite used for this lining was of the following composition :—

	Per cent.
Alumina	53·62
Peroxide of iron	42·26
Silica	4·12

On the working side of the rotative furnance is a tap hole for discharging the slag into the pit below, where it is received in vessels mounted on wheels. At the two extremities of the cylindrical rotative chamber with its truncated ends are large orifices, one of which, on the side of the regenerators, serves for the introduction of the heated gas and air, as well as for the exit of the products of combustion, while the other facing the working platform, is closed by a stationary door, hung before it in the usual manner. Although the passage for the introduction of the gases in combustion is separated only by a vertical partition-wall from the passage through which the products of combustion are led away, the chamber is heated very perfectly, care having been taken that the gases enter the chamber with a certain velocity, which sends them forward towards the door, and makes them reach the exit passage only after having traversed the rotative chamber to and fro.

This rotative furnace is worked as follows:—The ore to be melted is broken up into fragments not exceeding the size of peas or beans; to it is added lime or other fluxing material in such a proportion that the gangue contained in the ore and flux combine with only a little protoxide of iron into basic and fluid slag. A charge of, say, 20 cwt. of ore is put into the furnace when fully heated, while it is slowly revolving. In about 40 minutes this charge of ore and fluxing material will have been heated to bright redness, and at the same time from 5 to 6 cwt. of small coal of uniform size are added to the charge, whilst the rotative velocity is increased, in order to accelerate the mixture of coal and ore. A rapid reaction is the result; the peroxide of iron being reduced to magnetic oxide commences to fuse, and at the same time metallic iron is precipitated by each piece of carbon, while the fluxing materials form a fluid slag with the siliceous gangue of the ore The slow rotative action is then again resorted to, whereby the mass is turned over and over, presenting continually new surfaces to the heating lining, and to the flame within the rotator.

During the time of this reaction, carbonic oxide gas, besides the hydrocarbon contained in the coal, is evolved from the mixture of ore and carbon, and heated air only is introduced from the regenerator to effect the combustion of this gas within the rotating chamber. The gas from the gas producers is entirely, or almost entirely, shut off during this portion of the process. When the reduction of the iron ore is thus nearly completed, the

rotator is stopped in the proper position for tapping off the fluid cinder; after this the quick speed is imparted to it, whereby the loose masses of iron contained in it are rapidly collected into two or three metallic balls. These are taken out and shingled in the usual way of consolidating puddled balls; the furnace is tapped again, and is ready to receive another charge of ore. The time occupied in working one charge rarely exceeds two hours; and, supposing that 10 cwt. of metallic iron is got out per charge, the apparatus is capable of turning out at least five tons of puddled bar per diem. If anthracite or hard coke is available for effecting the reduction of the ore, it should be crushed much finer than when coal or brown coal is used, the idea being that each particle of the reducing agent should be fully consumed during the period of chemical reaction. If wood is used, it has to be charged for the same reason in larger pieces.

If it is not intended to make iron, but cast steel, the balls may be transferred from the rotator to the bath of a steel-melting furnace in their heated condition, and without subjecting them to previous consolidation under a hammer or shingling machine. It is feasible, however, to push the operation within the rotator to the point of obtaining cast steel. If this is intended the relative amount of carbonaceous matter is somewhat increased in the first instance, so that the ball, if shingled, would be of the nature of puddled steel, or contain even some carbon mechanically enclosed. If, now, after removing the cinder by tapping, from 10 to 15 per cent. of ferro-manganese or spiegeleisen is thrown in, and the heat within the rotator is rapidly raised by urging the influx of heated gas and air from the regenerator, the metallic balls will soon be seen to diminish, and presently a metallic bath only will be found in the furnace, which may be tapped into moulds, and be hammered and rolled into steel blooms or bars in the usual manner. For the production of cast steel on a large scale, it will, however, be more profitable to transfer the metallic balls to a separate melting furnace, a series of rotating furnaces working in concert with a series of steel-melting furnaces, to produce charges of five to eight tons of fluid steel.

Mr. Siemens has stated that the action of the rotating chamber would be the more perfect the larger the capacity of the chamber, and that experience had already confirmed this view. An experimental furnace which he erected at Birmingham, having only a capacity to hold 9 cwt. of ore, did not give as uniform results or as large yields as the 1-ton furnace here described, and, considering that no hand-labour is involved in the working of the furnace, there is no reason why the capacity of the chamber should not be increased to 2-ton charges, yielding, say, 18 cwt. of metal in three balls; the division of the charge into three balls being produced by two annular internal lines of projection forming part of the lining. These are so contrived that they can be renewed through doors in the periphery, without cooling down the furnace, or disturbing the remaining portion of the lining; they are necessary also in order to prevent the charge from sliding.

In the introductory portion of a paper read by Mr. Siemens before the Iron and Steel Institute in the opening of 1873, and to which we are indebted for many of the particulars above given, he showed that upon theoretical grounds, one ton of iron ought to be producible with half a ton of coal, and one ton of cast steel with 18 cwt. of coal. According to the process here described, he added that these results would be obtainable, barring losses by radiation, imperfect combustion, and imperfect absorption of heat in the regenerator; but, although he had not yet been able to determine accurately the amount of fuel consumed in the gas producers, he felt confident that one ton of iron ball was produced in a full-sized rotator, working continuously with a total consumption of fuel not exceeding 25 cwt., and that one ton of cast steel would be produced with a consumption of 40 cwt. of common coal. For comparison of this result with other known methods, the following synoptical table, prepared by Mr. D. B. Lewis Gordon, F.R.S.E., was exhibited during the reading of the paper just referred to, as showing what has been the consumption of fuel per ton of iron produced from the earliest time to the present day.

SYNOPTICAL TABLE of the Fuel Consumed in producing One Ton of Wrought Iron.

(a.) Charcoal; by the Ancient Direct Process.

		Tons.			
		Maximum.	Minimum.	Mean.	Wood consumed, assuming yield of charcoal at 30 per cent.
	East Indian Forges	8.16	5.00	6.58	21.9
II.	Catalan	2.98	2.75	2.87	9.6
	Siegensche	4.40	—	4.40	14.7
	Styria and Carinthia	3.07	2.85	2.89	9.6
	Stückofen	4.00	—	4.00	13.3
	Chenot's process	2.90	2.66	2.78	9.3
III.	New process (Rotator)	—	—	—	2.0

(b.) Charcoal; by the Blast Furnace and Puddling Process.

		Blast Furnace.			Puddling Furnace.				
		Maximum.	Minimum.	Mean (adding 10 per cent. for loss of weight in puddling).	Maximum.	Minimum.	Mean.	Total mean.	Wood consumed, assuming yield of charcoal at 30 per cent.
IV.	Styria and Carinthia.	0.65	—	0.71	1.00	0.80	0.90	1.61	5.4
	Rhine	0.94	0.80	0.96	1.00	0.90	0.95	1.91	6.4
	Norway	1.30	—	1.43	—	1.00	1.00	2.43	8.1
	Sweden	1.10	—	1.21	—	1.00	1.00	2.21	7.4

(c.) Coal; by the Blast Furnace and Puddling Process.

V.	Silesia	2.50	—	2.75	1.00	—	1.00	3.75	
	Belgium	2.16	—	2.38	0.90	—	0.90	3.28	
	France	2.17	—	2.39	0.90	—	0.90	3.29	
	Scotland	3.00	1.95	2.72	1.00	—	1.00	3.72	
	Cleveland	2.17	1.45	1.99	1.00	—	1.00	2.99	
	Staffordshire	3.35	2.15	3.02	1.25	—	1.25	4.27	
	South Wales (Dowlais).	1.45	1.25	1.48	0.85	—	0.85	2.38	
	New Process (Rotator).	—	—	—	—	—	—	1.25	

Hitherto Mr. Siemens has confined his attention chiefly to the production of steel by this process, and in this he has been successful, producing by such means a steel of superior quality, equal to crucible steel. More recently he has been devoting himself to the production of wrought iron, and an important feature of this process is the purity of the metal produced, notwithstanding the presence of objectionable matter in the materials employed.

That the Romans made iron in South Wales and Monmouthshire is proved by their slags found near Pontypool, where, in 1565, a charcoal blast furnace was erected by Capel Hanbury. The principal iron ore was for a long time the clay ironstone, of which about 50 seams, from 2 in. to 6 in. thick, occur in the coal measures, between the millstone grit and the lower 4 ft. seam of Dowlais, and 1 ft. thick between this and the 9 ft. seam of Mountain Ash. Blackband seems to have been discovered here by David Mushet, in 1842, and first smelted by Charles Hampton, at Maesteg and, only later, at Cwm Avon, Tondû, Garth, Dowlais, and other works. This ironstone is found, 16 in. thick, over the celebrated Navigation upper 4 ft. seam, and 54 in. thick

in two banks quite on the top of the coal measures. Brown iron ores were taken from the mountain limestone of South Wales and red hematite from Dean Forest.

The first coke blast furnace in Monmouth seems to have been started at Pontypool in 1740, and in 1788 there existed only three in the whole county, these making 2,100 tons of pig a year, while six coke blast furnaces in South Wales made 6,600 tons of pig iron. The first furnaces were here built at Cyfartha in 1770, by Anthony Bacon. Then followed other iron works; in 1784 Pen-y-darran, in 1790 Blaenavon, built by T. Hill & Co., and in the same year Ebbw Vale, Blaendare, and Plymouth, in 1795 Nant-y-glo, in 1803 Beaufort and Clydach, and Varteg, in 1805 Tredegar, in 1824 Blaina, in 1825 Pentwyn, in 1827 Abersychan, in 1828 Bute, in 1837 Golynos, in 1838 Victoria, and in 1840 Aberdare, while the anthracite furnaces of the Swansea Valley, as we have seen, date all after 1836. The production of South Wales and Monmouth, which in 1788 was only 8,700 tons, had risen in 1828 to 297,512 tons, in 1836 to 354,112, in 1857 to 970,727, and in 1872 to 1,057,315 tons of pig, made with anthracite, coal, and coke, in 122 blast furnaces, out of 165.

Passing now to our colonies, we noticed at Vienna, in the Indian department, some samples of excellent iron ores from Madras, amongst which was magnetic iron ore from the Kandschamalley mountain near Salem, where a bed 100 ft. thick crops out and is worked open cast. The Salem Iron Works showed samples of white charcoal pig iron, as did the Porto Novo Iron Works of Madras. Of very great interest were the exhibits of native iron industry, presented by the local committee of Mysore and Madras, and illustrated by a neat model of a native iron works. This showed a wolf furnace about 4 ft. high, which is supplied with blast from three pairs of hand bellows, and will produce a lump of iron of about 50 lbs., after some hours' smelting. This bloom is re-heated in a charcoal fire, cut into several billets and hammered out into marketable merchant bars. The process is of course very imperfect, and entails a great loss of metal, but the iron obtained is very tough and pure. There was also another sample of wrought iron made in Upper Assam in a similar wolf furnace from red hematite, while the Mohamed Bazaar Iron Works of Beerbhoom exhibited white and grey charcoal pig iron and wrought iron made in an ordinary blast bloomery. Very good ores, comprising brown and red hematite and magnetic iron ore, were also shown from Karnul, Kadapeh, Kunjamullay, Umritsar, Mysore, &c., these demonstrating that India is by no means deficient in iron, and that the production from blast furnaces with coke would be possible on a large scale, if some of the bituminous kinds of coal were only freed from their impurities by a process of washing and dressing (which we recommended in our previous section on mineral fuel)* before they are subjected to the coking process, as is now largely done in England and on the Continent. From New Zealand we noticed in the collection of the Colonial Museum specimens of magnetic iron ore from Dun Mountain, Nelson, from a vein in mica schist at Wakatipu Lake, Otago, and from Maramara, Firth of Thames, together with a piece of charcoal pig iron, and an iron bloom. There were also samples of titaniferous iron sand from Taraniki, specular iron ore from Nelson and Otago, and red and brown hematite from Auckland and Collingwood, Nelson. Although raw materials are apparently plentiful, the manufacture of iron in New Zealand seems hardly to have begun as yet.

We come now to France, where the use of iron was known long before the Conquest by Julius Cæsar, who states that the Veneti, who inhabited the southern part of Brittany, employed with their ships anchors, which were fastened to them by iron chains instead of cables (*ancoræ pro funibus ferreis catenis revinctæ*). This statement shows clearly that the art of making iron must have arrived at a certain degree of perfection in ancient Gaul a century before the Christian era, that is some 2,000 years ago. It seems that ore bloomeries, which make wrought iron direct from the ore, are still in existence in the Arriège and the Pyrenees, while charcoal blast furnaces are almost exclusively employed for the reduction of iron ores in Champagne, Lorraine, Franche-Comté, Berry, Périgord, and Biscay. The use of coal in

* See Section II.—Mineral Fuel.

smiths' fires dates in the Forez as far back as the 14th century; coke blast furnaces, however, were only erected in the beginning of our century in the Forez, Saône-et-Loire, and Loire departments.

Though France owns excellent iron ores, she is obliged also to import of them largely. Thus in 1872 she obtained not less than 99,500 tons from Belgium, 163,500 tons from Spain, 232,800 tons from Algiers, and 111,686 tons from Italy. Her production of pig iron in the same year amounted to 1,181,262 tons), of which 1,002,600 tons was coke pig iron, made by 113 blast furnaces, and only 178,662 tons of charcoal pig, produced in about 90 furnaces, principally in the Haute Marne and Berry. The French iron industry was, on the whole, very well represented at Vienna, though only a part of her iron works exhibited. Amongst them the celebrated establishment of Messrs. Schneider, at Creusôt, Saône-et-Loire, takes the first place. The Creusôt works include 13 coke blast furnaces, which are fed with iron ore from various sources, such as oolithic ironstone from Mazenay, Saône-et-Loire, brown hematite from Chanteloup and St. Florent, in Berry, spathic iron ore from Maurienne, in Savoy, specular iron ore from Elba, and magnetic iron ore from Mokta-el-Hadid, near Bona, province of Constantine, Algeria, while the excellent marble of Gilly serves as a flux. Creusôt commands, therefore, a number of rich and good iron ores, and is consequently enabled to turn out products of first-rate quality. The fuel is coke, made at the works, in Appolt coke ovens from a mixture of bituminous coal derived from the basin of St. Etienne, with washed coal slack of a rather dry sort of coal from Creusôt. This latter does very well in the forges and rolling mills, but it makes an indifferent coke, and contains a quantity of ashes, which therefore, are removed by the process of washing and dressing by machinery. Schneider & Co. own collieries at Creusôt, Montchanin, Longpendu, Decize, Montaud, Brassac, and Beaubrun, and in 1872 they obtained from them 715,000 tons of coal. The production of the blast furnaces in the last-mentioned year was 180,000 tons of grey and white pig, from which about 90,000 tons of wrought iron, principally rails, and 60,000 tons of steel, chiefly Bessemer steel, were obtained. The company employs 15,500 men and 308 steam engines of 19,000 aggregate horse power. A speciality exhibited was ferro-manganese, which was stated to contain as much as 70 per cent. of manganese; it is made in a Siemens' furnace, by introducing into a bath of molten pig iron charges of charcoal and manganese ore. A great portion of manganese combines, however, with the slags, which contain over 25 per cent. of that element, and are utilised in the mixture for the blast furnaces.

Considerable interest was created at Vienna by the collective exhibition of 16 firms of the Loire, representing the metallurgical industry of that department, amongst which firms we may name the Acieries et Forges de Firminy, J. Holtzer and Co., and Limousins Brothers, of Firminy; Arbel député, Brunon Brothers, Deflassieux Brothers and Peillon, Marrel Brothers, Russery and Lacombe, all of Rive-de-Gier; Bellard and Co., the Fonderies Forges et Acieries de St. Etienne, and Révollier, Biétrix and Co., of St. Etienne; the Fonderies et Forges de Terrenoire; Harel and Company, of Givors and Vienne, Isère; Jackson Frères et Cie., of Pont-Salomon; Eug. Imbert and Co.; and C. Tapounier, of St. Chamond. Of these firms the Firminy Company produces 21,600 tons of pig iron annually, which is worked up into railway material and in Siemens-Martin steel for ordnance, &c. The St. Etienne Company has blast furnaces at Givors and produces with them Bessemer steel pig iron for its Bessemer and Siemens-Martin steel works at St. Etienne. Harel and Co. make forge pig iron of good quality in two blast furnaces at Pont l'Evéque; and at Givors they produce annually 18,000 to 20,000 tons of spiegeleisen from rich manganiferous iron ores derived from the department of Isère, Spain, Elba and Mokta, in Algeria. The manufacture of this speciality has become very profitable in the Loire, as the "spiegel" is largely consumed by the steel works. It appears that the production of spiegeleisen, which not long ago was confined to Prussia, was first begun at the furnaces of St. Louis, near Marseilles, about 1866, by M. Jordan (who visited the Siegen district in 1864, where he learnt its manufacture), by the introduction of manganiferous ores from Almeria and Murcia in Spain, Corsica, and Algeria. He also succeeded in making grey

Bessemer pig which rivals the best Barrow hematite iron. According to an analysis made by M. de Vathaire, such Bessemer pig (*a*) and spiegeleisen (*b*) contained :

	a	*b*
Graphite. - - - -	3·426	0·527
Carbon - - - - -	0·210	4·679
Silicium - - - - -	4·895	0·402
Sulphur - - - - -	0·015	0·005
Manganese - - - -	0·836	7·270

The Société Anonyme des Hauts Fourneaux de Marquise exhibited excellent coke foundry pig and large castings, such as pipes and tubbings for the lining of circular pits, and similar articles were shown by the works of Haldy, Kœchlin, and Co. of Pont-à-Mousson and of the Société Métallurgique de Vienne. The provinces of Algeria contains some very rich iron ores, as specular iron ore at Djebel, near Arrousse and Sfer, in the province of Oran and magnetic iron ore at Mokta-et-Hadid, in the province of Constantine, where in 1872, over 200,000 tons of excellent ores were raised, while the total export of iron ores from Algeria was about 391,000 tons. The sole Algerian iron works, which deserve to be named are at Atélik, near Bona, in Constantine, where pig iron is produced from spathic iron ore and coke made from native coal.

The exhibition of Spain was extremely rich in excellent iron ores, and it appears that she produced in 1869, 311,000 tons, from which about 40,000 tons of pig iron were made in blast furnaces, and about 15,000 tons of wrought iron by the direct reducing process in Catalan bloomeries. About one-half of all the ores raised was exported from Murcia, Almeria, and the Basque provinces to France and England. Catalonia and the Basque provinces still produce the greater part of the forge iron made in Catalian bloomeries, while the other provinces have more or less adopted blast furnaces, which are mostly fed with charcoal. Only a few iron works exist which employ coke, as, for instance, those of the Compania de Minas y hierros del Pedroso, near Seville, which make forge pig from magnetic iron ore and hematite, and the Fabrica de hierros de Guilhon Numa, at Mieres, near Oviedo. Here grey and mottled forge pig iron are produced from ores containing 40 to 45 per cent. of metal, with coke which is made from washed coal. The furnace is blown with hot blast, and a charge of 920 lb. of coke will bear a burden of 1,200 lb. of ore, and 552 lb. of limestone. It was remarkable to find amongst the Spanish exhibits rather good samples of charcoal spiegeleisen and manganiferous white pig iron. Thus from the province of Murcia specimens were shown by Manuel Herrero, of Mazarron, and Riccardo Navarro; from Cartagena by the Sociedad San Fulgencio, Francisco Vidal, and the Compania John Cockerill, and from Aguilar by the Sociedad Anguileña and Alhorppe Bakier. Besides rich iron ores from Catalonia, Sommorostro, near Bilboa, Santander, Granada, and Cartagena, there were samples of ordinary charcoal pig and wrought iron, exhibited by Lopez Peregrin, of Cobeta, and Roman Morencas, of Checa, near Guadalajara, by Francisco Richard of Burgos, Manuel Blandin y Carrese, of Vera, in Navarra, who smelts red hematite and specular iron ore, and by Francisco Dampilo of Almeria. The Spanish iron industry appears to be still in a very backward state, and as wood is beginning to be scarce everywhere in the country, and charcoal dear, there is no other way left than to establish large iron works in the coal districts, that is in Asturias in the north, and near Seville in the south. Portugal exhibited no samples of iron or iron ore at Vienna.

Italy is almost in the same condition as Spain; she owns very great riches of first-class iron ore, her vegetable fuel is, however, getting scarce, and the mineral fuel which she possesses is not fit for use in blast furnaces, with very few exceptions. The production of Italy during 1872 was only 26,000 tons of pig iron, exclusively made with charcoal, though there are in the north of Piedmont, near Aosta, beds of good anthracite, which may be utilised in blast furnaces. In Lombardy there were celebrated iron districts even in the time of the Romans, the works being situated near Bergamo and Hrescia, the Bergomum

and Brixia of the ancients, whence the Roman knights got their steel swords, while to this day Bergamask and Brescian steel is highly appreciated in Italy. Almost as much wrought iron is produced in Italy by the direct reducing process in ore bloomeries, as pig iron is made in blast furnaces, the latter operation being carried on principally in Corsica, Sardinia, Tuscany, and the Principato Ulteriore. Blast furnaces, however, came first into use in Lombardy.

The chief iron ores in Lombardy are spathic iron ore, or carbonate of iron, and brown hematite, which are found in beds, enclosed by metamorphic gneiss in the neighbourhood of the lakes of Como and Iseo, and in the Val Sassina, and also in the Bergamask mountains, where they compose layers or seams, some times two, even three fathoms thick, in triassic red sandstone, or green slate. The latter ore contains much manganese, and is, therefore, particularly suitable for the production of a kind of manganiferous spiegeleisen or a white radiated pig iron. The principal places where this ore is raised, are near Pisogne (where a bed three fathoms thick is worked), in Val Camonica, Val Trompia, near Loveno and Malonno, and in Val di Scalve. From these localities Peter Morandi, of Valle Bondione, near Bergamo, sent samples of iron ores and pig iron; and Benedetto Grassi and Fiarino Scabrino, of Schilpasio and Derso, showed a collection of iron ore, pig iron, and steel, their produce being 500 tons of pig and 60 tons of steel per annum in charcoal forges. Cavaliere Giovana Andrea Gregorino, of Lovere, near Bergamo, exhibited raw and calcined spathic iron ore, grey and white manganiferous pig and spiegeleisen of very good quality; from this grey pig any spiegeleisen puddled steel is made, while the ordinary white and mottled pig iron is converted into wrought iron in charcoal forges. Giovani Maria Damioli, of Pisogne, near Brescia, exhibited likewise samples of spathic iron ore, spiegeleisen, and other kinds of charcoal pig, while Calino Ragazzoni and Co., of Pazarre, in Val Trompia, and Guiseppe Ferrari and Co., of Vobarno, near Brescia, presented specimens of similar iron ores and pig iron of equally excellent quality. The same may be said of the exhibits of Ludovico Corneliani, of Bormeo. A splendid collection of specular iron ore, red hematite, and magnetic iron ore was shown by the Mining Company of the Island of Elba, of Portoferrajo. This island has, from its eastern shore, at Rio Albano, Rio Marina, Terranera and Capo Calamita, during 25 centuries, supplied enormous quantities of rich iron ore, from which the Etruscans made iron long before the foundation of Rome; and it is estimated that, if even a million of tons of ore were taken away from these ore deposits every year, they would last as long again before being exhausted. The oldest mines are those of Rio Marina, where rich ore is still picked out from the heaps of old Roman refuse, these heaps being 500 ft. high. The ore bed rests here upon talcose schist, and is covered by limestone; it is several hundred feet thick, contains chiefly specular iron ore and red hematite, and covers an area of over 30 acres, while it is not known to what depth it reaches down. At Rio Albano and Terranera lodes of specular iron ore break through the talcose schist, and cover it with beds of the same material, from 30 ft to 100 ft. thick, and at Capo Calamita there is a lode of magnetic iron ore, which, rising from the level of the sea, intersects a thick crystalline limestone, sending frequently apophyses or branches into the latter, and surmounting it by a large bell-shaped mass, which attains a thickness of 150 ft., and is chiefly composed of specular iron ore, red hematite, lievrite, actinolite, and green garnet. The production of the iron mines of Elba in 1872 was nearly 200,000 tons, of which quantity, however, over 160,000 tons were exported to Corsica, France, England, and Germany. Only one-fifth part is smelted in Tuscany, at Follonica, Cecina, Valpiana, and other places. What an enormous iron industry might have arisen out of this wonderful mineral wealth, if nature had only provided Italy with a suitable mineral fuel.

We have lastly to notice a few exhibits of iron from Atripalda and Montella, near Avellino, in the Principato Ulterior of Naples, these being samples of products made in ore bloomeries. As the direct reducing process as effected in Italian bloomeries is little understood out of the country, a few words about it may be acceptable. While in the Catalan and Biscayan bloomeries the iron

ore is reduced and smelted into a bloom of malleable iron in one continuous operation, the Italian iron smelters begin their day's work by reducing to the metallic state in one operation the whole mass of ore which is necessary for four blooms, and by calcining at the same time the ore, which is intended for the morrow. The reduced ore is then spread over the floor of the forge, cooled with water, and only so much of it returned to the fire as will be required for one bloom. Thus, in one bloomery about 4 cwts. of iron are obtained from 8 cwts. of iron ore in a day, or 1·20 to 1·25 tons in a week. The operation is as follows:—A semicircular hearth, or hollow, of 30 in. to 32 in. diameter, and 7 in. deep, is made in the bloomery from charcoal slack, which is tamped hard, the tuyere being in the middle of the straight side. The hearth is then filled up with pure charcoal slack 3 in. to 4 in., and 5 in. from the nozzle a 6 in. layer of round charcoal sticks 5 in. long is arranged like a fan; this is surrounded by a semi-ring of calcined and broken up iron ore several inches thick, and again surrounded by another semi-ring of charcoal slack 4 in. wide, the whole being closed in by a wall made of lumps of raw ore, the interstices of which are filled up with slack. Six of such fan-shaped layers are piled upon each other until they reach a height of about 3 ft., and form a kind of semi-circular furnace, which is built up of charcoal ore and charcoal slack, leaving a hollow space of 5 in. diameter before the tuyere wall. Through this hollow or shaft burning charcoal is introduced, covered with fresh fuel, and a gentle blast turned on; this fuel, as it burns away before the nozzle is constantly renewed by pushing it down with an iron rod, and filling up afresh. The object is to keep the shaft always filled with charcoal, so that no undecomposed air, but only hot burning gases can reach the inner ring of ore. After three to four hours the operation is finished, the outer wall of raw ore, which by this time has become sufficiently calcined, is pulled down, the outer slack removed, and the lumps of reduced ore are drawn out and cooled with water. The hearth is now cleaned, filled up with fresh charcoal to 18 in. over the tuyere, some lumps of reduced ore are laid opposite the latter upon the fuel, and the blast turned on. In this way, in four to five hours, one quarter of the reduced ore is melted down and collected upon the bottom as a pig or "massello," the slag having been occasionally tapped. The massello is then taken out and hammered into a square bloom of about 1 cwt., which, during the next smelting operation, is reheated in the same fire, and hammered out into a bar of very tough merchant iron. The quality thus obtained is very good, the process, however, is very slow, and is attended with a great waste of fuel and iron.

Switzerland is very deficient in good iron ores and in mineral fuel. Of the former she only possesses some secondary deposits of iron oolite and bean ore which are found in cavities of the jurassic limestone in Bern, Solothurn, and some other cantons, and raised to a quantity of about 8,000 tons annually. The Ludwig von Roll Iron Company of Solothurn owns three charcoal blast furnaces at Gerlafingen, Clus, and Olten, and one coke blast furnace at Choindez, which smelt iron ores, containing 43 per cent., and produce from them about 3,500 tons of castings, and 4,000 tons of forge pig iron, which is converted into wrought iron in charcoal forges. The quality of the samples exhibited at Vienna seemed very good.

We propose next to examine the iron exhibits from Belgium, a country which in 1871 produced over 565,000, and in 1872 578,400 tons of pig iron, while in 1849 its produce was only 148,500 and in 1847 248,400 tons. It appears that iron was made by the ancient Belgians even before Julius Cæsar went to war with them, as old iron slags are frequently met with upon some hillocks in the province of Brabant at Nieuwe Rhode, between Louvain and Aerschat, and in the province of Antwerp at Tessenderloo, where brown hematite and bog ore seem to have been smelted. During the Roman occupation iron works existed in the province of Namur at Mossée, Halloy, and Lustin, near Dinant in the Boeq valley, at Vodecee in the province Entre Sambre-et-Meuse, and at Kenlen in Luxembourg; at all these places heaps of iron slags have been found, together with unmistakeable indications of their origin: and at Lustin, between Namur and Dinant, two Roman air bloomeries were discovered as recently as 1870, together with their contents. They were

on the top of a hill, and consisted of an oval hollow or hearth, 12 ft. long, 9 ft. wide, and 3 ft. deep, from which a channel covered with stones, led to the hillside in the direction of the prevailing wind, thus serving as a blast pipe. These bloomeries contained pigs of iron with 93·5 per cent. of metal and 6·5 of slag and impurities. Wolf furnaces existed in the valley of the Meuse as early as the 10th century, and charcoal blast furnaces were in use in the 14th century, when Count William of Namur, in 1345, granted great privileges for the utilisation of the forests to the then existing furnace at Worth, near Namur. During the wars which Charles the Bold of Burgundy waged in the 15th century for the conquest of Lorraine (in 1460), all iron works were destroyed by his soldiers, but a hundred years later, in 1560, 35 blast furnaces were at work again in southern Belgium. Count Philip of Namur gave repeatedly privileges to the ironmasters in 1635 and later, and, about 1700, cast-iron ordnance was made in the province of Entre Sambre-et-Meuse by some iron works. The rapidly increasing scarcity of charcoal in Belgium gave rise also to experiments with coal as a fuel at Julenville in 1769, and at Bouvignes, where Amand made 12 tons of pig iron with coke alone in 1800, while other smelters employed it mixed with charcoal. About that time the quadrangular section of the blast furnaces was replaced by the circular form, they were heightened from 15 ft. to 25 ft., and with the introduction of cylinder blowing machines the charcoal furnaces were enabled to produce three tons of pig iron in a day. The use of coke had, however, dropped again into oblivion, and it was only in 1826 that John Cockerill started the first permanent coke blast furnace, at Seraing, near Liége, which was soon followed by another in the province of Namur, each making between five and six tons of pig iron daily, or 2,000 tons in a year. In 1830 there existed in this province (besides the coke furnace), 40, and in Luxembourg 21 charcoal blast furnaces, while in 1847 Belgium owned 62 coke and 69 charcoal furnaces, of which 50 and 35 were in blast respectively. Out of that number the province of Hainaut possessed 30, Namur 9, and Liége 23 coke blast furnaces, and the annual production of a furnace had risen to 4,000 tons on the average; while in 1872, 26 furnaces were in blast in the Liége, and 30 in the Charleroi districts (Hainaut), making about 10,300 tons each in a year. The charcoal furnaces are rapidly dying out.

Of the Belgian iron works which were represented at Vienna, we must name in the first place the celebrated works of Seraing, near Liége, the creation of John Cockerill, who thus became the father of modern Belgian iron industry. Born at Haslington, in Lancashire, in 1790, he came as a young mechanic to Antwerp, and was so prosperous as to start in 1820 an engine factory in the then deserted episcopal palace at Seraing. In 1826 the first blast furnace was blown in, and there are now five of them in operation, while four others are under erection. The situation of Seraing upon the coal-bearing strata on the bank of the river Meuse, and in connexion with several canals and railways, is very favourable for such large iron works. The company owns four coal mines, which reach to a depth of 500 yards, and from which 2,400 men raise annually 350,000 tons of coal with the assistance of 24 steam engines, representing 900 horse-power. From part of this production 140,000 tons of excellent coke are prepared (in 143 horizontal and 216 vertical Appolt's coke ovens) for consumption in the blast furnaces. The latter produce 55,000 tons of forge and foundry pig iron, and employ 400 men and 15 steam engines of 480 horse-power, for the purposes of blowing, lifting the ore, pumping, &c. The iron ores, which are smelted here, are brown hematites from the province of Namur, red hematites from Vezin, oolitic ore from Luxembourg, and others from foreign countries. These raw materials and samples of pig iron made at Seraing, were arranged in a trophy in the Machinery Hall of the Exhibition. We may add, that the Seraing Company produces besides 40,000 tons of rails and 11,000 tons of Bessemer steel.

We may mention next the Société de l'Espérance, who own near Liége, four large blast furnaces, and from their own coal and iron mines produce between 25,000 and 30,000 tons of pig iron of all binds. Their produce consists, however, mostly of forge pig, which is consumed at the extensive puddling works of the company. The specimens which were exhibited

showed very good quality, and were particularly adapted for the manufacture of plate and sheet iron. The Société de Scléssin, which was founded in 1837, possesses six blast furnaces admirably situated between the Namur railway and the river Meuse, by which they are supplied with brown iron ore from the "terrain anthraxifère," near Huy and Namur, and with limestone from Chokier on the Meuse. The furnaces are of the Belgian pattern, square, and of pyramidal shape, 50 ft. high and 15 ft. wide, with three tuyeres, and provided with blast of 3·5 to 4 lb. pressure from five beam blast engines of about 500 horse-power. Their production varies from a dark grey foundry pig to white radiated forge pig, from which most excellent wrought iron for girders and W shaped bars, of 20 metres length is made. The company of Ougrée produces from four Belgian furnaces (which are 54 ft. high, 9 ft. wide at the top, and 14 ft. at the boshes) chiefly white forge pig of excellent quality, which is consumed at the company's forges and rolling mills for the production of first-rate tyres, axles, plates, and sheets. The iron ores are brown hydrates from Namur, Entre Sambre-et-Meuse, Engis, and Teux, but principally red hematite, or "minerais violet," which forms at Vezin a bed of great purity and regularity, 2 metres thick, between a blue slate and a yellow quartz rock, belonging to the upper Devonian strata. This iron ore is oolitic and yields from 45 to 48 per cent. of iron, but owing to a supposed amount of phosphorus, it only made pig iron of inferior quality, until the manager of the works, M. Schütte, in 1852, introduced into the mixture a certain quantity of shales from the coal measures for the formation of sufficient slag, when the yield and the quality were considerably improved. It was also at these works that in 1849 the use of burnt lime instead of limestone, was first introduced by Messrs. Emil Schmidt and Montefiore Levi with great economy. The improving action of the burnt carboniferous shale with respect to the quality of the white pig iron, is due to the introduction of a considerable amount of alumina in the slag, as the following analyses will show. Good crystalline slags were composed, *a* from the old, *b* from the new mixture of—

	a	*b*
Silica	42·75	42·70
Alumina	9·09	20·23
Lime	38·19	30·81
Oxide of iron	2·77	3·72
Magnesia	0·74	1·10
Manganese	4·64	1·24
Potassa	0·39	0·30

The Société de Marcinelle et Couillet makes, at Couillet and Châtelineau, near Charleroi, very good pig iron from Belgian and Luxemburg iron ores, and uses it chiefly for the manufacture of rails and girder iron. The same is the case with the Société de Zone, at Marchienne, and the Société de Jemmapes, near Mons. Both showed very fair samples of pig iron, for the production of which the Luxemburg oolitic ironstone, resembling the iron ore of the Cleveland district, and of which we shall speak presently, was used to a large extent. The importation of foreign ores into Belgium seems to be greatly on the increase, and the yield of the native mines on the decline, since the production of pig iron had increased over 100,000 tons in the years 1865 to 1870, while that of native ore had fallen off from 1,018,231 tons in 1865, to only 653,332 tons in 1870, so that the importation of foreign ores, chiefly from the Duchy of Luxemburg, must have amounted to at least 600,000 tons to make up for the difference. It appears that this is caused by the growing claims of the ground owners, as equivalent for the leases for the utilisation of their mineral grounds.

We come now to the department of the German empire, and begin our review with the iron works on the left bank of the Rhine, which are next to Belgium and France. We may notice first the Concordia Iron Works, at Ichenberg, near Eschweiler, on the Aachen-Cologne Railway. They were erected in 1853, and consist of three blast furnaces of Belgian pattern with 85 coke ovens, which produced in 1872 about 25,000 tons of pig iron. The fuel comes from the adjoining mines of the Eschweiler Coal Mining Com-

pany, and the iron ore partly from layers in the mountain limestone, partly from the red hematite mines of Nassau, and from the Siegen district. The produce is almost exclusively white forge pig of excellent quality, and readily saleable to the several puddling works between Aachen and Eschweiler. Eberhard Hoesch and Sons, of Düren, the owners of the large puddling and steel works of Eschweiler and Lendersdorf, work four small charcoal blast furnaces at Lendersdorf, and the Eifel mountains, which yield about 2,000 tons of charcoal pig iron of good quality, which is used for steel making. We have next to mention the Neusser Iron Works, at Heerdt, near Düsseldorf, which were erected in 1858, under the skilful management of the brothers Conrad and Franz Büttgenbach, who in 1865 carried out here first their well-reputed system of blast furnaces. At Vienna we found a good model of this system, together with an excellent collection of iron ores used at the Neusser works, and samples of pig iron, from dark grey Bessemer and foundry, to white forge pig.

The model of the Büttgenbach furnace just referred to is illustrated by Plate XXVII., while Fig. 6, Plate XXV., is a perspective view showing the general arrangement. As explained in a paper read in 1873 by Mr. F. Büttgenbach before the Iron and Steel Institute, "the fundamental idea of this mode of construction, and the advantages of the system may be summed up as follows:—(1.) The mason work of the stack is quite independent of the blast furnace proper. Each ring or course of bricks constituting the hearth, boshes, and inside wall, is readily accessible, and free from any casing, except as regards a small portion, measuring from 3 ft. to 4 ft. in height, at the widest section of the blast furnace. Consequently, the whole of the above several parts are completely bare, and easily reached for any purpose required, even while the furnace is in active operation. This feature conduces to the duration of the furnace, for in case of need any injured part can be repaired, even when the furnace is at work. (2.) The inside wall and the upper part of the boshes being cooled by the atmosphere having access thereto, they remain in their normal condition without wear, and do not become unduly heated at any time, being, therefore, indefinitely kept in a state of preservation, since there never occurs a fusion of materials at this height. (3.) The hearth, and the lower portions of the boshes, being apt to suffer after a certain time from the destructive action of the materials in a melting state, may be replaced without any difficulty whatever while the work is going on, so that there is no occasion to apprehend any extinction of the fires so long as the in-wall is not destroyed. If putting out the fires should at any time become necessary, the hearth and the boshes could be renewed without affecting the in-wall injuriously. (4.) Each particular brick being accessible during the working of the furnace, and the progress of the fire easily ascertained, corrosions can be obviated by cooling down with water thrown on the several parts, or by means of water vessels or tuyeres wherein the water circulates placed within these parts as far as the inside of the furnace, whereby the wear and tear can be checked. (5.) The utilisation of the gas at the furnace mouth can be so managed as to make it yield the best results. The pillars supporting the platform of the furnace top are gas pipes, and drop into sheet-iron vessels fixed to the summit of the base of the stack where it slopes away. These vessels are open on one side, so that when filled with water up to a certain height, they can be shut down by means of a valve, measuring a few centimetres square The gas issuing forth out of the furnace mouth finds its way into these receptacles, and in its passage through them travels over a large surface of water. Here it deposits the dust while a great part of the water suspended in the gas, in a state of vapour, is condensed. Consequently, the gas reaches its destination in a highly purified condition, and may yield the very best results in those parts where it is desired to make use of it. The arrangement of the said water receptacles allows of the withdrawal of the dust or grit deposited while in full working, and in the event of an explosion, the area of from five to six millimetres of the water column paralyses, as though it were a gigantic valve, any injurious effects. In point of fact, instead of dreading, we rather wish for explosions from time to time, since

they serve the purpose of clearing off the dust and grit that may still be clinging to the inner walls of the pipes. Moreover, there is the advantage of confining these subsidiary appliances to a spot on the works, which does not in any way interfere with the general progress of the manufacture. (6.) The gas pipes being supporters also of the platform surrounding the furnace mouth or top, render the said platform independent of the blast furnace proper, and that without involving any special outlay." Mr. Büttgenbach has also introduced in connexion with his blast furnaces a peculiar description of closed hearth, which admits of ordinary working, as well as working with a closed hearth. This arrangement, which Mr. Büttgenbach has used since 1867, is illustrated on Plate XXVII., and has given excellent results. Its application is very simple indeed, and free from the objectionable features of other methods, since the work of the bottom of the furnace can be performed, in case of need, without depending upon the mouth of the tuyere for running off the slag, as will be seen from the engravings. The hearth is closed in by a cast-iron tymp placed in the usual position. This tymp arch is cooled by a current of water passing through a coiled iron pipe fixed in the cast iron. In the centre of this plate there is an aperture or orifice measuring $\frac{3}{4}$ in. running almost over the entire height, and the cooling pipes are situate as near this kind of slit as may be. This slit is closed up by means of ordinary clay, and the upper portion of the slit is placed 2 in. or 3 in. higher than the centre of the line of the tuyeres. The slag of the blast furnace, ascending above the dámstone and reaching the level of the tuyeres, runs off easily through a hole driven by means of a light steel bar into the said slit; and, since the level of this hole may be altered at will, a means is thus afforded for changing the level at which the slag is run off over a range of 24 in., which is a very great advantage in itself; while, in addition, there is nothing to prevent the melted metal from being tapped at this same slit.

The performance of Mr. Büttgenbach's furnaces at the Neusser Works and elsewhere has been excellent, an economy of 10 to 15 per cent. of fuel being effected by them, while of course the first cost of the furnaces themselves is much below that of ordinary types. Mr. Büttgenbach states that with good coke excellent No. 1 foundry pigs have been produced from ores yielding 35 per cent., the consumption of coke being in the ratio of 11 parts to 10 parts of pig, and the blast having a temperature of 660° Fahr., while in the case of white pig it is one part less of good coke to every part of pig. The blast furnace at the Neuss Works has more than once been suddenly blown out for several weeks, owing to causes quite foreign to its working capabilities. Three of these suspensions occurred during the war in the year 1870–1871, owing to the want of fuel, and no preparatory arrangements were made before any of the said suspensions of work. They lasted during a space ranging between three and ten weeks respectively. Mr. Büttgenbach did not touch the blast furnace during any of the periods of stoppage referred to, the most prolonged of them occurring at a time when the thermometer registered 10° to 17° Centrigade, and yet when work was resumed the furnace did its work again with surprising regularity. On the last occasion, however, it was necessary to raise up the tuyeres, in consequence of the thickening of the bottom stone. The blast furnace at the Neusser Works had entered upon the eighth year of its existence in 1873, and the condition of its core was then such as to promise a further endurance of twice or three times that period. The walls, be it borne in mind, are but weak, measuring no more than 2 ft. thickness at the base, and 18 in. of the inner wall. This thickness they have not lost during an existence of eight years. Experience has shown, moreover, that the core of the furnace being exposed to the air, the internal heat produces hardly any effect upon the bricks, either by dilation or contraction. Hearth, boshes, and inner-wall were originally fastened together in the Neuss blast furnace by means of flat iron binders occurring at the third course alternately. This precautionary measure however appears superfluous, and about 1869 Mr. Büttgenbach had the binders removed at the hearth and boshes, as well as at the in-wall, in part. There are now nine such furnaces working in France, two or three in Austria, and a number more are under erection in other countries.

To return, however, to our survey of the German iron works and their

products. The Quint Iron Works, near Trier, on the Moselle, belonging to Adolph Krämer are over 100 years old, and contain five blast furnaces, besides a large forge and rolling mill. They made in 1872 18,000 tons of pig iron and 22,500 tons of bar iron, chefly rails, girders, and other sorts, employing 1,200 men. To Krämer Brothers belong the St. Ingbert Iron Works in the Bavarian Palatinate, which have existed since 1785, and which now own five blast furnaces, producing about 20,000 tons of pig iron, besides 112 coke ovens, a large forge and mill, and important iron mines. We have next to name the Neunkirchen Iron Works, near Saarbrücken, belonging to the Brothers Stumm. They were erected in 1872, and have been the property of the present owners since 1806. There are six blast furnaces blowing and two others under construction, besides 286 coke ovens, a foundry, and a large rail mill, employing 2,000 men in all. The production is about 20,000 tons of pig iron, 40,000 tons of railway, and 900 tons of hammered bar iron. The age of the iron industry, near Saarbrücken, is very great, and dates from Roman times; during the last century, however, it has been largely extended. Thus iron works were erected at Stahlhammer in 1755; Halberger Hütte in 1756; Blechhammer in 1758; the use of coke in blast furnaces became general since 1846, and minette ore was first smelted at Burbach in 1856. The Luxemburg Mining and Saarbrücken Iron Company, of Burbach, possesses large iron mines in Luxemburg and at Nancy, besides red hematite mines in Nassau, and in four large blast furnaces which were erected in 1856, over 50,000 tons of forged pig iron are produced, with Saarbrücken coal, which is coked in 131 coke ovens. In four large furnaces, which were erected in 1856, over 50,000 of forge pig iron are produced annually. The daily yield of each blast furnace has, since 1862, increased from 20 to 70 tons. There is also a forge with 56 puddling and 21 balling furnaces, which turn out 42,000 tons of railway, girder, T, and other kinds of wrought iron, of which large girders 70 ft. long were exhibited at Vienna. The Dillingen Iron Works, near Saarbrücken, were founded in 1763, and own important iron mines near that place, in Nassau, Luxemburg, and France, smelting the iron ores produced by them, in one blast furnace at Dillingen, two at Geishautern, and two at Hohenrhein, in Nassau. The speciality of the puddling works connected with Dillingen are excellent iron plates and sheets, the latter being partly coated with tin, lead, and copper.

The adjoining Grand Duchy of Luxemburg has of late become a very considerable iron producer; and while in 1865 it only made 69,350 tons, it produced in 1870, 150,000 tons; and in 1872, with 23 blast furnaces, 300,000 tons of pig iron. The largest furnaces (built after the Cleveland pattern) are at Esch-on-the-Alzette, and produce 85 to 90 tons daily. This growing blast furnace industry is based upon the excellent coal of Saarbrücken and the rich beds of oolitic iron ore, which rival the famous ore deposits of the Middlesbrough district. The beds of this ore, called "minette," are found between strata of marl, belonging to the upper lias formation, and they extend in Luxemburg over 18 English square miles in a shallow basin, so that a great part of them can be worked open cast. The basin of Esch and Rimlingen contains two ore beds; the upper, being 8 ft. thick, consists of brown and red hematite. the lower, 13 ft. thick, of grey, blue, and green hydro-silicate of iron or glauconite, which are so much mixed with lime that no flux is required in smelting them. In the basin at Differdingen and Rodingen both beds join together and attain a thickness of 32 feet. The beds of "minette" are nearly horizontal, and beginning near Longwy, in France, they extend in the Grand Duchy over Hüssingen, Rodingen, Rimelingen, and then turn southward into Lothringen, and following the plateau, which towards the west is confined by the river Moselle, can be traced as far as Novéant and Nancy, in France. It is estimated that Luxemburg owns 8,900 acres of oolitic ironstone, of which over 60 per cent. can be worked open cast, and Lothringen 22,400 acres, for the greater part only adapted for underground mining. Lothringen owns 35 large blast furnaces, of which, in 1872, only 26 were in blast, while in Elsass there existed only six charcoal furnaces, the production of the former being 212,000 tons, and of the latter only 8,000 tons of pig iron.

The greatest firm of ironmasters in Lothringen are Messrs. de Wendel, who

have 16 large blast furnaces at Hayingen, Moyeuvre, and Stiringen, which are exclusively supplied with oolitic minette ore, and coal and coke from Saarbrücken. The produce is principally a very cheap forge pig, which is converted into wrought iron in 103 puddling furnaces, belonging to the same proprietors. The Lothringen Iron Company, formerly Dupont and Dreyfuss, of Ars-sur-Moselle, near Metz, work six blast furnaces at St. Paul's and St. Benoit for forge pig, which is also consumed by their own puddling works. Karcher and Westermann own likewise two blast furnaces at Ars and one at Novéant, and produce iron of the same quality as above and with the same materials. This is also the case with five furnaces at Oettingen, near Diedenhofen, which are leased by Count Hunolstein to Messrs. Jahiet, Gorand, Lamotte, and Co., with one blast furnace of Bauret, Lejeune, and Co., at Audun-le-Tiche, and at Hemingen, near Saarburg, where two furnaces exist, belonging to Messrs. Lusson, Salmon, and Co. In Elsass the firm of Dietrich and Co. owns six blast furnaces at Niederbroun, of which four are worked with charcoal and two with mixed fuel; the firm have also one charcoal furnace at Mutterhausen, in Lothringen. The ores which are smelted here come for the greater part from Nassau and Siegen, and only a small quantity of oolitic hematite from Nancy and alluvial iron ores are used. The pig iron is of first-rate quality, and is converted into wrought iron, puddled steel, Bessemer steel, and cast steel at Jaegerthal and Mutterhausen. At Lützel, near Pfirt, are the two small charcoal furnaces of Mr. Paravicini, and besides these blast furnaces there are in Elsass not less than 31 iron foundries, employing 154 cupolas, the five foundries at Mülhausen, Grafenstaden, Gebweiler, Bitschweiler, and Alt-Thann, producing alone 18,000 tons of castings for engines and machinery.

We go now over to the right bank of the Rhine, and find in Southern Germany only a few iron works in Würtemburg and Bavaria. The Wasseralfingen Iron Works of Würtemburg, which are celebrated for the early application of hot blast, and the utilisation of the blast furnace gases by Bergrath Fabre du Faur as early as 1828, showed at Vienna a collection of their iron ores, chiefly brown hematite and Jurassic bean ore, which are smelted with charcoal and Saarbrücken coke, for foundry pig iron and castings; while the Koenigsbronn Iron Works, which have similar materials, made an excellent show with samples of cast iron, and of their celebrated chilled rollers for steel and other rolling mills.

In Bavaria it is principally the Maximilianhütte Company, near Regensburg, which deserves special mentioning. This company possesses one charcoal furnace at Rittenau, in the Upper Palatinate, which makes 2,000 tons of pig iron, besides three coke blast furnaces at Rosenau, with 35,000 tons, and two at Unterwellenborn, in Thuringia, with 13,000 tons of annual produce, amongst which is some spiegeleisen. The iron ores smelted are spathic and brown iron ore, red hematite, specular and magnetic iron ore, with an average yield of 40 per cent. The company makes also 5,000 tons of Bessemer steel, and 43,000 tons of rails and bar iron. The Achthal Iron Company of Achthal, Hammerau and Hohenaschau, in Upper Franconia, make from their charcoal and coke blast furnaces chiefly all kinds of excellent castings for engines and machinery, soft rollers and chilled rollers for steel mills, but they also produce some forge pig iron, which they consume themselves in their forges.

Going again northward we have to mention the Main-Weser Iron Works at Lollar, in the Grand Duchy of Hesse, which belong to Messrs. Buderus Brothers. In 1872, the two blast furnaces at these works produced 25,000 tons of forge and Bessemer pig iron from Nassau red and brown hematite ore, and with coke from Westphalia. The same family own also blast furnaces in Nassau and the Germania puddling works and rolling mills at Neuwied on the Rhine, which were erected in 1844, and almost exclusively make plate and sheet iron.

The district of the River Lahn, in Nassau, is one of the oldest iron countries of Europe. Before 780, iron works—probably wolf furnaces—

existed in the neighbourhood of Wetzlar, where a very renowned iron was made by a guild of "forest smiths," who had their special privileges, kept an iron mart at Wetzlar, and sent their products regularly to the great annual fairs of Frankfort-on-the-Main. This iron industry was especially flourishing during the 13th, 14th, and 15th centuries, but came almost entirely to ruin through the Thirty Years War. From this district, which in 1872, with 12 blast furnaces produced over 30,000 tons of pig iron, we found exhibits made by the Neuhoffnungshütte of W. E. Haas and Son, of Herborn, whose works were built in 1810, and who from their own red iron-stone make excellent foundry and forge pig iron in a charcoal blast furnace. The adjoining district of the Middle Rhine is also rich in iron ore, and it was here that at the Rasselstein Iron Works near Coblentz, the first puddling furnace in Germany was started in 1824, the first bar mill in 1825, and the first rail mill in 1835. Several important iron works of that district are now in the hands of Friedrich Krupp, of Essen. Amongst them we name, in the first place, the former Government iron works of Sayn, consisting of a charcoal furnace already existing in the last century, and which produces spiegeleisen, and a coke blast furnace, which was erected in 1818, and was probably one of the first of its kind in Rhineland. It is connected with a foundry and engine works, and derives excellent spathic and brown iron ores from the celebrated mines of Horhausen, which are worked upon lodes occurring in the lower Devonian or Coblentz strata. Their production is about 3,600 tons annually. The next of Krupp's iron works is that of Mülhofen, at Engers-on-the-Rhine, where, in 1865, a Belgian coke furnace was built by the Prussian Government. Since it was acquired by Krupp, three large Scotch furnaces with pneumatic lifts, and a daily production of 45 to 50 tons of Bessemer pig iron or spiegeleisen have been added. The ores are partly supplied from the Horhausen, partly from the owner's Nassau red hematite mine, while the fuel is coke from the Ruhr basin, and the flux marble from the Devonian limestone formation at Vilmar in Nassau. The average yield of the mixture is 44 per cent., and the produce either dark grey Bessemer or white radiated steel pig iron and spiegeleisen. Not far off is the Bendorferhütte with one blast furnace of antiquated construction, which, however, has not been in operation of late, while the Hermannshütte at Neuwied has one furnace of Belgian and two of English pattern. The raw materials and pig iron produced are of the same kind as at Mülhofen.

Following the course of the Rhine, we find, opposite Bonn, the iron works of Friedrich-Wilhelmshütte, near Siegburg, of the Sieg-Rhine Iron Company. The works were started in 1833, and now possess two blast furnaces, which smelt tertiary clay ironstones and Siegen and Nassau ores with coke made on the spot from Ruhr coal, in Appolt and François coke ovens. Since 1860 the furnaces have been provided with regenerative heating apparatus of the Cowper-Langen construction. The annual production is about 20,000 tons of forge pig and spiegeleisen, which are consumed by the puddling works of the company. The Bochum Mining and Cast-steel Company own the Mülheim Iron Works, near Cologne, where the experimental "Raschette" blast furnace was tried in 1864 by Mr. Charles Aubel, but owing to exceptionally unfavourable circumstances did not attain to its well-merited success. There are now two blast furnaces of English construction, 50 feet high, 9 and 11 feet wide at the top, 15 and 16 feet at the boshes, and 5 ft. between the tuyeres, which are four in number, 4 in. diameter, and blow 4-lb. pressure blast, of a temperature of 600 deg. Fahr. at the furnace. The heating apparatus is of the Osnabrück pattern. The fuel is coke from the Ruhr basin, and the iron ore comes from the Siegen and Nassau districts, and even so far as from Mokta in Algiers, and Elba. The production of each furnace is about 35 tons of spiegeleisen daily for the consumption of the steel works of Bochum in Westphalia.

We come now to say a few words on the exhibits of the iron works of the far-famed Siegerland, which was well represented by a collective exhibition at Vienna. The iron industry of the principality of Siegen can be traced back over 1,000 years, and as early as 1288 a steel forge is mentioned at the

town of Siegen, the latter being in existence before the 11th century. The oldest furnaces were wolf furnaces; it seems, however, that the low kind of blast furnaces with closed breast had come into use in this country at a very early date, probably about the middle of the 13th century. The celebrated mine, Stahlberg, of Müsen, gave its annual tithe before 1313 to Count Henry, and the iron mines of Eiserfeld are mentioned in 1496, those of Eisern in 1537, while the privileges and rights of miners and ironmasters were regulated already by the Siegen mining law of 1535, and the Nassau-Katzenellenbogen law of 1559, the latter having remained in force until 1865. The celebrated iron and steel ore consists chiefly of manganiferous carbonate of iron or spathic iron ore, which at the outcrop of the lodes is generally converted into brown iron ore to a depth of 10 to 15 or 20 fathoms from the surface. There are over 500 of such lodes known in the district, extending in a belt of 46 miles in length and 23 miles in width, from north-east towards south-west through the lower Devonian formation. There are also lodes containing excellent red hematite and specular iron ore, their number, however, is more limited. The lodes are seldom over 3 fathoms thick, generally much less, and the lode of the Stahlberg mine alone reaches a thickness of 20 fathoms. In 1872 this district produced over 700,000 tons of spathic iron ore, 170,000 tons of brown iron ore, and 36,000 tons of red hematite and specular iron ore, which were very well represented at Vienna by over 50 mines.

Amongst the smelting works, we notice in the first instance those of the Cologne Müsen Company, which owns two charcoal furnaces at Lohe and Müsen — where spiegeleisen has been made from the ores of the Müsen Stahlberg for a couple of centuries—and three large coke blast furnaces of English pattern at Kreutzthal. Spiegeleisen is here likewise the chief produce, 30,000 tons being made annually for the use of German and foreign Bessemer steel works and for the production of puddled steel. The company raises annually 66,000 tons of steel ore from the Stahlberg, and employs 800 men. The Wissen Iron Company, of Wissen-on-the-Sieg, are proprietors of the very good mines of Wingartshaart, from which they raise 24,000 tons of iron ore, while at their two coke furnaces at Wiessen they produce from these and other ores 14,300 tons of spiegeleisen and nearly 10,000 tons of very good steel forge pig iron. H. F. Schneider is owner of the new Friedrichshütte, at Herdorf, with two large English coke furnaces, two small charcoal furnaces, and 38 very good mines; while the Rolandshütte, of Haardt, near Siegen, erected in 1866, possesses two large furnaces which make over 16,000 tons of spiegel and white forge pig, and the Charlottenhütte Company, of Niederschelden, started in 1864, produce from two furnaces 25,000 tons of spiegeleisen. The Heinrichshütte, at Au, on the river Sieg, belongs to the old firm of T. H. Dresler, which, in 1872, raised from their mines over 50,000 tons of iron ore, and produced from two coke furnaces 20,500 tons of spiegeleisen, with 10 to 11 per cent. of manganese and steel pig iron. It was here that, in 1842, spiegeleisen was first made with hot blast and charcoal, and, in 1862, with coke alone. The old Niederschelden Iron Works, belonging to Jacob Kreutz, of Siegen, who from his mines produces 75,000 tons of iron ore with 1,200 men were erected in the 16th century, provided with cylinder blowing machine in 1829, with steam power in 1855, and adapted to coke fuel in 1867. The quality of pig iron is the same as before. We have lastly to mention two works which were exhibited at Vienna, namely, the Meggen Iron Works, of Altenhunden, with one furnace and another building, and 6,500 tons of produce, and the Germaniahütte, of Gabriel Bergenthal and Co., at Grevenbrück, which with one furnace made 8,500 tons of white forge pig iron for their own use. There belong in all 46 blast furnaces to the district of Siegen, of which 25 alone, around the town of Siegen, produced in 1872 117,500 tons, viz., 53,500 forge pig iron and 57,500 spiegeleisen and steel pig iron with coke, and 6,500 spiegeleisen with charcoal.

We enter now the iron district of the Lower Rhine, which contains 35 large coke blast furnaces, which are mostly of modern origin, while their number will be shortly increased to 45. The Eintracht Iron Works,

of Hochdahl, near Düsseldorf, contain four blast furnaces, and were built in 1850. Three are constructed after the Belgian, one after the English system. They are provided with pneumatic lifts, Wasseralfingen hot blast stoves, heated by the furnace gases, and employ blast of 400 deg. Cels. (752 deg. Fahr.) and 3·5 lb. pressure. The iron ores come for the greater part from Siegen and Nassau, and are mixed with 10 per cent. of iron cinders and limestone from the upper Devonian formation of the neighbourhood, the coke being made from Westphalian coal and the annual produce coming up to 37,000 tons of mostly white forge pig iron. The Friedrich Wilhelms Iron Works, of Mülheim-on-the-Ruhr, produce with one furnace 2,400 tons of foundry pig, and four larger ones are under erection. The company owns likewise iron mines and extensive iron foundries and engine works, from which a number of blowing engines has been supplied to the several iron works of Rhineland and Westphalia. The annual production of pig iron will be in future over 90,000 tons. We meet next with a group of blast furnaces, on the bank of the Rhine, near Duisburg. The Niederrheinische Hütte owns four large furnaces, which make 30,000 tons of forge and foundry pig chiefly from Nassau red and brown hematite derived from the mines of the company, with triassic limestone from the Moselle and with coke made on the spot from Westphalian coal slack. The waste gases are utilised for the hot blast stoves and the steam boilers, and the heat of the coke ovens is also used for raising steam.

The next works to be noticed are the Johannishütte, of Friedrich Krupp, with four blast furnaces, each of which makes 35 to 40 tons per day of Bessemer and white steel pig iron from Nassau and Siegen ores. Six new furnaces are under construction, and the works will in future be amongst the greatest iron producers of Rhineland. The coke is made from Westphalian coal in 260 coke ovens. The firm has now 11 blast furnaces going, and will shortly have 18, which are supplied with choice iron ores from their own mines, of which 414 are in Siegen and Nassau. A considerable mining property, which is intended to yield 300,000 tons of iron ore, is owned by Krupp, near Bilboa, in Spain, and the large collieries of Count Beust, Ernestine, Friedrich Ernestine, and Hanover, in Westphalia, are likewise in his possession, the value of his total mining and metallurgical interests being estimated at seven million pounds, while the total number of workmen in his employ is 12,000.

The works of the Vulcan Iron Company, at Duisburg, have again four large furnaces; and from iron ore of various description and origin they make about 24,000 tons of all kinds of pig iron. Their exhibits at Vienna were accompanied by numerous chemical analyses, which showed instructively the compositions of the ores and smelting products. We have next to mention the extensive works of the Phœnix Iron Company, of Laar, at Ruhrort, which owns twelve blast furnaces, namely, four at Laar, erected in 1853, four at Kupferdreh in the same year, four at Borbeck, the first built in 1846, besides extensive puddling works and rolling mills at Laar and Eschweiler Aue, two collieries at Berge Borbeck, and 28 iron mines in Siegen and Nassau, with a production of 150,000 tons; amongst the latter is the celebrated red hematite mine of Gottesgabe, near Aumenau, which yields over 30,000 tons of ore annually. The furnaces of Laar made, in 1872 about 38,500 tons, those of Borbeck 20,000 tons of iron, mostly forge pig, while the furnaces of Kupferdreh were being transformed. Rich foreign ores are likewise smelted in these furnaces—for instance, specular iron ore from Elba, with 61 per cent., and magnetic ore from Mokta-el-Hadid, in Algiers, with 60 per cent., while poorer native ores, such as brown iron ores, contain only 47, clay ironstones 26 to 28, and limonites or bog iron ores from 32 to 45 per cent. of iron. The forge pig iron is puddled at Laar and Eschweiler, and mostly made into rails, while some of the suitable quality of pig is made into steel by the Bessemer and the Siemens-Martin process. The company gives employment to 3,000 workmen.

We now come to the important iron district of Westphalia, which, until the middle of this century, possessed but a few charcoal blast furnaces, of which those in the lowlands made only castings from phosphoric bog iron ore, while

a few others on the Ruhr made also forge pig iron. In 1853 there were not more than 12 furnaces in the district, of which only three were worked with coke, three with coke and charcoal mixed, and six with charcoal alone. The total production was 30,000 tons, of which 20,000 tons was coke pig iron. Westphalia now owns 39 large coke blast furnaces, several others are building, and their annual produce comes up to 425,000 tons of pig iron of all kinds. Sheet iron rolling mills were introduced at Spillenberg, near Steele, in 1800, puddling furnaces, 1827, at Wetter-on-the-Ruhr, 1835 at Hoberhausen, 1839 at Hörde, and rail mills, in 1843, at Hörde and Sterkerade. Steel was made in the puddling furnace first at Haspe, in 1846, and at Hörde in 1849.

We have next to note in this district the Gutehoffnungshütte Mining and Smelting Company, formerly Jacobi, Haniel and Huyssen, of Sterkerade, near Oberhausen, who have ten blast furnaces going, and make about 45,000 tons of foundry and forge pig iron from the blackband iron ore of the coal measures, near Essen, and from brown and red hematite and spathic ore of Siegen and Nassau. The company have also a colliery at Oberhausen, large puddling and rolling mills, Bessemer steel works, and a foundry and engine works at Sterkerade, besides a shipbuilding yard at Ruhrort, and they employ 8,500 men altogether. The old works of Sterkerade, with two charcoal furnaces, date from 1808, those of Oberhausen from 1853. Of even greater importance is the Union Iron and Steel Company, which owes its origin to the amalgamation of three distinct companies in 1872, viz., the Neu Schottland, Henrichshütte, and Dortmund Iron Companies. The company are proprietors of 18 blast furnaces, of which 12 were in blast in 1872, yielding 85,500 tons of pig iron of various kinds. There belong to them likewise the collieries of Glückauf and Carl Friedrich, near Dortmund, and very extensive iron mines, of which those in Westphalia produce blackband and clay iron-stone, the mines in Siegen and Nassau, the usual ores those of Rhineland brown iron ore, on the Harz oolitic brown iron ore, and the mines of Swabenswerk, in Sweden, magnetic iron ore of excellent quality.

The total output of the company's iron mines in 1872 was 239,000 tons There are three coke blast furnaces at Dortmund, four at Othfresen, four at Henrichshütte, near Hattingen, two at Horst, and two at Hasslinghausen, while of the three charcoal furnaces of the company two are at Bredelar, and one at Swabenswerk, in Sweden. Of puddling and rolling mills, which made 114,000 tons of rails, bar, plate, and girder iron, there are one each at Dortmund, Horst, Henrichshütte, and Aplerbeck, while a cast-steel works exists at Horst, and two Bessemer works are building at Dortmund and Henrichshütte. The works of the Hörde Mining and Smelting Company at Hörde, near Dortmund, consist of the puddling and rolling mills of Hermannshütte, which were erected in 1839, and of the Hörde blast furnaces, the two first were built in 1852. These works were founded upon the use of blackband ironstone, which had been discovered in 1848 in the coal measures of Westphalia, and as a trial of this ore, made at the old charcoal blast furnace Markana at Haspe, in 1853, had given very satisfactory results, it came rapidly into use at the furnaces of Kupferdreh in 1853, Hhörd 1854, Henrichshütte and Haspe 1855, and at Hasslinghausen in 1856. There are now thirteen seams of blackband ironstone known, which vary of course, considerably in thickness and quality; some contain rather considerable portions of phosphorus, and the ironstone with less than 30 per cent. is not used. The total production of blackband in Westphalia had, in 1872 risen to the respectable figure of 288,000 tons. The Hörde Iron Works were built and scientifically managed by the late A. Von Hoff, and were deservedly looked upon as model works for the iron industry of Westphalia and Rhineland, and their gradual development offers many interesting features to metallurgists. It is for this reason that we give in Figs. 1 to 8, Plate XXVIII., sketches of the shape and dimensions of the Hörde blast furnaces. They are constructed after the Belgian pattern, and were 48 ft. high, and 14·5 ft. wide at the boshes, and 10 ft. at the top. Originally they were blown only with two tuyeres, the furnace No. 4 having alone a third in the back wall, and two of them, Nos. 1 and 4, were built in the lower part of Belgian puddling stone, the others, Nos. 2 and 3, entirely of fireclay stones and bricks,

made at Garnkirk in Scotland. Figs. 1 and 2, Plate XXVIII., represent the furnaces Nos. 1 and 2, the first being now blown with five tuyeres in its fourth campaign, the other with six, and being now in its second campaign. They were blown in on the 27th of February and the 11th of June 1854, respectively. No. 3 was started in the same year in October, and No. 4 in December; the former has 6 tuyeres, and is now in the third campaign, while the latter has to this day never ceased to blow for 20 years, or ever since it was started. No. 5 was blown in in 1858, and has since then worked without interruption, while No. 6, which is represented by Figs. 7 and 8, Plate XXVIII., is now in its tenth year. The newest furnaces, Nos. 7 and 8, Figs. 9, 10, Plate XXVIII., are just being blown in with 5 tuyeres. Nos. 4 and 5 are open at the top, the others closed by various arrangements, of which the Parry hopper, as modified by Von Hoff, has given the greatest satisfaction. They will be easily understood from the sketches just alluded to.

At first calcined blackband was the sole iron ore used, and some difficulties had to be overcome, before a good grey pig iron could be obtained. This was at length done by fluxing the ore with so much limestone, that the slag became extremely basic instead of silicious, and this practice is still followed by most of the German coke blast furnaces, as the lime combines readily with the sulphur of the ore and fuel. In the second year other iron ores were added to the mixture, such as brown and red ore from the Devonian limestone of Iserlohn, bean ore from the chalk formation, oolitic brown ore from the Jurassic formation of Paderborn, bog iron ore from Lingen in Hanover, and others. Thus the daily average production was gradually increased from 17·5 tons in 1854, to 19·5 tons in 1856, and it is now 30 to 35 tons of white forge pig, or 25 tons of dark grey Bessemer iron. The Hörde Iron Company owns besides the eight blast furnaces—which in future will produce about 62,000 tons of pig iron annually, 164 coke ovens, a puddling and rolling mill with 154 furnaces, and Bessemer steel works with 8 converters. Blast is supplied by four horizontal, and one Hentschel beam blowing engines. Coal and blackband mines at Hörde and Hasslinghausen belong to the works, and also mines yielding carbonate and brown iron ores on the Hartz and in Siegen, and others of red hematite in Nassau. In 1872 the company produced 175,000 tons of coal, 36,500 tons of iron ore, 45,500 tons of pig iron, and about 150,000 tons of rails, tyres, bars, plates, &c., of iron and steel, by employing 3,600 men. Dark grey Bessemer pig with large graphitic secretions is made from a mixture of carbonate, brown and red iron ore, with 42 per cent. of Devonian limestone, from Lethmate, in the valley of the Lenne, and with 1·5 to 1·7 ton of coke for 1 ton of pig, which for ordinary forge pig, however, decreases to 1·2 or 1·3 ton. We have still to mention in this district the Neu-Oege Iron Works of Limburg, on the Lenne, which were founded in 1830, and with two blast furnaces in 1872 produced 13,400 tons of quality pig iron, mostly spiegeleisen. There is also a forge and rolling mill, and a foundry belonging to the concern, the latter producing excellent chilled rollers.

We have next to speak of some large iron works of the district of Hanover, the Georgs-Marienhütte of Osnabrück, the Ilsede Iron Works of Peine, and the Neustadt Iron Works. The works of the Georgs-Marien Iron Company were erected in 1856, near Osnabrück, and they now contain six large blast furnaces, of which five are regularly blowing. The works, of which we give a general plan on Plate XXIX., extend from east to west, following the valley of the Dute, and the ground on which they are erected is so situated on the southern slope of the valley that a small portion of the site is obtained from a cutting made into the slopes of the valley, whilst the greater portion is formed by an embankment, or filling, of about 40 ft. in height. Such an elevated position for the works seemed to be convenient, not only for the intended arrangement of the coke furnaces and the ore stores, but also for the deposition of the slags, by means of which a considerable portion of the ground has, and is still being raised with very little expense. The difference in height between the lower level of the works, upon which the coke ovens, the stores for coke and mixed ores are situated, and the upper level containing the blast furnaces and all the other buildings of the works is 8 ft. 6 in.

The coals from the upper level may thus be carried in small trucks, without lifting, over the coke ovens, and may be shot directly nto the latter, whilst the coke from the ovens, may also be conveyed, without raising or lowering, through cuttings or tunnels under the buildings to the hoists of the blast furnaces. This difference in the height of the ground also allows the ores to be brought in a similar manner from the waggons directly into the crushing machines, from which they are delivered on the lower level, and are then conveyed in the same way as the coke to the blast furnace hoists.

The coke ovens and the ore stores are therefore placed at the eastern end of the works, then follow towards the west the steam boilers and blowing engines, the blast-heating stoves, the blast furnaces, the covered pig-beds, and lastly the engineering shops and the foundry. The offices for the administration of the iron works as well as the central stores depôt are situated at the southern side of the establishment. Even with the present development of the works with six blast furnaces, a space of 700 × 450 ft. is still available for further extensions between the large building for the administrative staff and the furnaces and shops, &c. The following are the detailed references to the general plan of the works on Plate XXIX.:—A, coal depôt; B, coke ovens; C, coal-washing machines; D, steam boilers; E, blowing engines; F, covered pig beds; G, blast furnaces; H, ore depots; I, ore-mixing shed; J, general stores; K, weigh bridge; L, locomotive shed; M, offices; N, O, P, Q, mechanical workshops; R, joiners' shop; S, carpenters' shop; and T, foundry.

Besides the six blast furnaces already mentioned there is a new furnace after the Büttgenbach principle under construction, this being entirely cylindrical and open at the top, a wide iron cylinder of 7 ft. diameter, however, being inserted in the centre of the mouth, this cylinder reaching 9 ft. deep in order to collect and carry off the waste gases. The same arrangement exists already with the two latest furnaces, which are 58 ft. 3 in. high from the ground level to the platform, 6 ft. wide between the tuyeres, 15 ft. at the boshes, and 15 ft. at the top, being quite cylindrical. Every furnace is provided with three hot blast stoves, which contain 32 suspended heating pipes each 10 feet length, these giving 1,400 square feet of heating surface in each stove. The latter thus easily heat the blast to 350 or 400 deg. Cels. (662 to 772 deg. Fahr.) This pattern of heating stoves, which is illustrated on Plate XXIX., was first introduced at these works, from which they take the name.

Views of these furnaces are given on Plate XXX., which will fully explain their arrangement.

The blast is supplied by five large horizontal blowing engines of 78 in. to 108 in. diameter, and 6 ft. to 7 ft. stroke of the blowing cylinders. The largest of these engines was constructed at the engineering works of Count Stolberg, at Ilsenberg, in 1870, and it is illustrated in Plate XXXI., and Fig. 1, Plate XXXIII. The steam and blowing cylinders are 51 in. and 108 in. in diameter respectively, and the stroke is 7 ft. The blowing piston it will be noticed is very light, being formed of a cast-iron frame having arms of I section covered on both ends by wrought-iron plates $\frac{5}{8}$ in. thick. The packing is of leather and felt combined, the felt being outermost, and the packing rings thus made being fixed on segmental pieces of poplar, which are screwed together, so that the packing rings are held firmly between them. Within the wooden packing blocks is placed an iron ring $\frac{1}{4}$ in. thick, this ring being made up of pieces of plate connected so as to allow of a certain amount of expansion or contraction; and upon this ring press a series of 12 springs, arranged as shown in Fig. 5, Plate XXXI. The arrangement of the inlet and outlet valves for the blowing cylinder is shown by Fig. 1, Plate XXXI., and by Fig. 1, Plate XXXIII., while Fig. 6, Plate XXXI., shows the inlet valves to a larger scale. From this latter view it will be seen that each of the inlet valves is attached to stems, which are slung by a pair of links from fixed centres above the valve. These suspending links are attached to the stems close to the valve, while further back another link connects the outer end of the stems to a fixed point below the valve. The effect of this is that the inlet valves are left free to lift quite away from their

seats, as shown in the longitudinal section. The delivery valves, on the other hand, are simple flap valves of india-rubber hung by their upper edges and closing on gridiron seats. The engine is provided with a flywheel 30 ft. in diameter and weighing 29 tons 18 cwt., of which weight 17 tons 10 cwt. is in the rim, while it is worked with steam at 45 or 46 lb. per square inch, cut off at $\frac{3}{5}$ths of the stroke, and is run at a speed of from 20 to 22 revolutions per minute. The blast is supplied at a pressure of from $4\frac{1}{4}$ to $4\frac{3}{4}$ lb. per square inch. The performance of this engine has proved highly satisfactory.

It was at the Georgs-Marienhütte that Director Lürmann first introduced his system of closed front for the furnaces and slag tuyeres with water cooling. The coke is prepared at the works from washed Westphalian, Ibbenbüren, and Deister coal in 300 coke ovens constructed on the Françoise system, the waste heat of which is utilised for steam purposes. 200 of these ovens are each 22 ft. long, 2 ft. 7 in. wide, and 5 ft. high; but the 100 ovens most recently constructed are 22 ft. long, 6 ft. 6 in. high, and but $16\frac{3}{4}$ in. wide. Of these latter ovens we give views on Plate XXXII. These furnaces have in the side walls vertical flues, but the gases are carried off from under the beds through two ports for the accumulation of the gases, one on each side of the furnace. The alterations in the dimensions and arrangement of the new furnaces have been adopted in order, first, to increase the production upon the same surface; secondly, to use also, at the increased pressure and heat in the higher and narrower furnaces the best bituminous coals from the government mines near Ibbenbüren, and from some of the Westphalian mines; and, thirdly, by carrying off the gases from both sides of the furnace to effect a more uniform distribution of the heat. The former furnaces, of a width of 2 ft. 7 in., and with intermediate walls 2 ft. 5 in. thick, horizontal flues, and a length of 22 ft., are coking on a surface of $22 \times 5 = 110$ square feet, four tons of coal in the average time of 42 hours; whilst the new furnaces with a width of $16\frac{3}{4}$ in., a thickness of the intermediate walls of $13\frac{1}{4}$ in., are coking on a surface of $22 + 2\frac{1}{2} = 55$ square feet in 30 hours, an equal quantity of four tons of coals. The quantity of coke is, of course, in both systems in proportion to the quality of the coals used for coking, and varies between 65 and 72 per cent; a greater heat is now attained through the smaller width and greater height of the new ovens, and the coals being under pressure in the ovens, a less bituminous coal may be coked in larger quantities, together with a more bituminous coal, The coking in the shorter time of from 24 to 36 hours concentrates a considerable heat in the smaller coke ovens, whence it becomes necessary to use for this system of ovens the best fireproof material that can be obtained from the best works in England.

The iron ores used at the Georgs-Marienhütte are the brown iron ore and carbonates of the Hüggel hills, and are found not far from the works in the Permian formation, constituting a bed of nine fathoms in dolomite, which is composed of spathic ore at the bottom, compact brown hematite in the middle, and soft brown ore on the top; they are exceptionally free from impurities, and contain 28 to 32 per cent. of iron, besides a considerable amount of manganese. The mines are worked open cast, and in 1872 produced 225,000 tons of ore. The production of five furnaces was over 50,000 tons of dark grey Bessemer and white forge pig iron, and varies from 35 to 40 tons per day per furnace with an average consumption of 1·8 to 2 tons of coke per ton of pig iron. The limestone, which is used as a flux, contains 10 to 12 per cent. of iron, and is quarried on the spot.

A speciality of the works consists in the utilisation of the blast furnace slags by granulating them in a stream of cold water. The sand thus obtained is used by the Osnabrück Trass Works for making cement and artificial stone. A great quantity of slag is also made into slag wool by blowing a jet of steam through the running slag, the steam spinning it into thin threads, which it carries into a chamber, where they are deposited, thus making an excellent material for jacketting steam and blast pipes. The company sell their excellent Bessemer pig to the Osnabrück and Westphalian Steel Works.

The Ilsede Iron Works of Gros-Ilsede, near Peine, were started with two blast furnaces in 1860, while a third was blown in, in July 1872. The former are 50 ft. high, 6 ft. between the tuyeres, 16 feet at the boshes, and 9 ft. at the top, while the latter is 50 ft. high and 18 ft. at the boshes, and 14 ft. at the top, with a contents of 8,600 cubic feet. The former furnaces are provided with four water tuyeres of 7 in. diameter, the latter with six of 12 in. diameter, the blast being supplied at a temperature of 400 deg. Cels. (772 deg. Fahr.), by horizontal twin engines. The coke is made at the works from the excellent coal of Obernkirchen, and used in big lumps and still hot from the ovens. The iron ore is the so-called bean-iron ore which is found in the chalk formation, between the Hills clay and marl, forming beds 20 to 32 ft. thick, which at the mines of Büchen and Adenstadt are worked open cast, and produce ore at about 1*s.* a ton, whilst one workman is able to raise 7,500 tons annually. The ore is intimately mixed with carbonate of lime, and requires no flux; its yield is 36 per cent. on average, but it also contains a considerable amount of phosphorus and manganese. The daily production of the furnaces has been increased from 32 tons in 1867 to 94 tons in 1872, by using much and strongly heated blast, together with Lürmann's slag tuyeres. In 1872 the total produce of three furnaces was 55,000 tons of pig iron, and 850 men found employment at the works and mines. The pig iron is somewhat similar to the Luxemburg pig, but as it contains from 3 to 5 per cent. of manganese, and the latter only 0·2 to 0·5 per cent., it is eagerly bought by the puddling works as a cheap raw material. We subjoin an analysis of Ilsede pig iron and of its slag. The former contains iron 90·860, manganese 4·144, silicium 0·133, phosphorus 2·895, sulphur 0·101, and carbon 1.170; the latter, silica 28·01, alumina 11·30, protoxide of iron 0·75, protoxide of manganese 11·17, lime 41·49 magnesia, 2·14, sulphur, 2·52, phosphorus 1·32. The cost of making a ton of pig iron is from 35*s.* to 40*s.*

Lastly the Neustadt Iron Works, which belong to the German Mining, Iron, and Steel Company, were founded in 1856, with the intention of using peat charcoal as fuel in the blast furnace, an attempt which, however, was not remunerative. The blast furnace was started again in 1869 with coke, and it smelts bean iron ore from the Neue Hoffnung mine, and other ores, producing white pig iron, which is consumed at the puddling works of the company, who have a second blast furnace under construction.

The Hartz mountains are also rich in excellent iron ores, of which we found, at Vienna, a good collection in the exhibition of the Clausthal mining district. They belong partly to ore deposits between Silurian slates and eruptions of diabase, and consist then chiefly of red hematite, or they are connected with the upper Devonian limestone and tuffæ of diabase, and compose then large beds of red, brown, and magnetic iron ore and spherosiderite. Such is the case at the Büchenberg mine near Elbingerode, where the bed is over 15 fathoms thick at the outcrop, and known to exist for a length of three miles; again at the Hartenberg and at Rothehütte, Mandelholz, Susenburg, at Kuhbach and Stahlberg near Blankenburg, and at the Golsterberg, near Altenau, where a bed, 10 fathoms thick, is explored. The iron industry of this district seems to be very old, and to have existed already at the time of Charlemagne, while charcoal blast furnaces came into use in the 17th and 18th century. The works of late, however, have much declined in consequence of the competition of the coke blast furnaces in other countries. The Hartz district is not yet sufficiently opened by railways, but if this be done, it will, at no distant time, become an important feeder of the iron works of Northern Germany. The same may be said of the Thuringian mountains where, in the tenth century, bloomeries and wolf furnaces, and in the 14th, blast furnaces were in existence, while the iron and steel of Schmalkalden and Henneberg was renowned over the whole continent. Owing to the increasing dearness of wood, and the competition of other works which command mineral fuel, this industry has almost died out, but a considerable export of iron ore is preparing. There are important deposits of magnetic and red iron ore at Schmiedefeld, connected with beds of garnet in gneiss, red and brown iron ore in lodes traversing the syenite in several localities, and lodes of

carbonates and brown iron ore at Altenstein, Rennstiegerberg, Flossberg, Brotterode, &c. Spathic iron ore and brown hematite are found in lodes and irregular beds in the Silurian formation near Saalfeld, Schwarzburg, and Gräfenthal, and also in the Permian formation at Stahlberg near Seeligenthal and Schmalkalden, where a bed of iron ore, connected with ferruginous limestone and dolomite, is explored, 600 fathoms long, 60 fathoms deep, and from 20 to 40 fathoms thick. The same deposits continue to Mommel, Elmeroda, and Auwallenburg, and also are found at Karnsdorf, Könitz, and Aue-am-Berg, where these beds are of great importance. We look next at the Saxon Erzgebirge, which is very rich in good iron ores, although iron making appears to have never attained there to a great extension. These iron ores belong in the western parts to contact deposits, between diabase and Silurian slates, and consist of red hematite in a belt from Zwickau to Elstersberg, 14 miles long, and 4 to 6 miles wide, while the great tract of diabase, stretching from Elster over Plauen to Hof in Franconia, contains also numerous lodes of brown and spathic iron ore. The most important iron ore deposits, however, belong to the granite and gneiss regions, and are chiefly arranged in four large groups, consisting of thick lodes of red hematite ore, viz., those of Schwarzenberg, Breitenbrunn, Rothgrube, and Riesenberg, which extend together over more than 40 miles in length. Rich magnetic iron ore is found in beds of clay slate and gneiss at Berggiesshübel, and it is smelted there in charcoal blast furnaces by the Saxon Cast Steel Company of Döhlen, and also raised by the Saxon Iron Company of Pirna. The most important iron works in Saxony, near Zwickau and the Plauen Grund, were not represented.

We conclude our sketch of the German iron exhibits with the Prussian province of Silesia, which, in the Riesengebirge and the Sudeten mountains, owns considerable beds of magnetic and red iron ore and of specular iron, at Schmiedeberg connected with granite and beds of garnet in gneiss, and also at Kupferberg and Altenberg, while a thick bed of brown iron ore is found at Haberlehne, at Volpersdorf, near Glatz, and diluvial bog iron ore is largely dug in the plains of the province of Lower Silesia for the consumption of a dozen charcoal blast furnaces in the district of Liegnitz, which make from that ore, annually, about 10,000 tons of foundry pig for castings, such as stoves, pots, pans, &c. The iron made from the bog ore contains generally too much phosphorous to be fit for anything else than such light castings. The district owns a single large iron works, Vorwärtshütte at Hermsdorf, near Waldenburg, which has five coke blast furnaces, and makes a very good forge and foundry pig iron from the magnetic iron ore of Schmiedeberg, which was there reduced to iron in ore bloomeries as long ago as the 12th century. Of other ores blackband from the coal measures of Gablau and Hermsdorf, clay iron ore from those of Waldenburg, red hematite from Jauer with 50 per cent., and some bog iron ore from Frankenstein are employed besides the Schmiedeberg ore which yields 50 to 54 per cent. of iron. The coke is made from washed coal of the Glückhilf mine on the works, and the limestone used as a flux comes from the Cretaceous formation of Oppein or the Trias limestone of Gogolin.

The iron industry of Upper Silesia, which is now of very great importance, is of comparatively recent date. Though ore bloomeries were certainly in use in 1365, blast furnaces were first erected in 1718; but the quality of the wrought iron made from the ores of the district had such a bad reputation, that until 1777, its importation in the other provinces of Prussia was prohibited. The first charcoal blast furnace was blown in at Halemba, 1718, at Kutschau, 1721, and at Stahlhammer and Sausenberg a few years later. The iron works of Malapane and Creutzburg date from the middle of the last century, and in 1780 Upper Silesia was in possession of 36 charcoal furnaces, which made 5,000 tons of pig iron, and of about 20 ore bloomeries, producing 3,000 tons of wrought iron, while no coal mine was yet being worked. Following the advice of Oberbergrath (afterwards minister of state), Count Reden, who had travelled in England, and there seen the early development of coke blast furnaces, Frederick the Great cared much for improving the iron industry of Silesia, and his successors upon the throne had the first

steam engine from England introduced in 1788, and the colleries of Kœnigsgrube opened in 1791, while the first coke blast furnace upon the continent of Europe was built in 1794, and blown in at Gleiwitz in 1796. The two first coke blast furnaces at Kœnigshütte were started in 1802, to which those at Hohenlohe and Antonienhütte soon followed. The last ore bloomery was laid cold for ever in 1798, and the puddling process introduced at Kœnigshütte in 1843. There exist now 48 coke and 21 charcoal blast furnaces in Upper Silesia, the former of which in 1871, produced 217,000, and the latter 13,600 tons of pig iron. The iron ores of Upper Silesia are of various kinds, but they consist principally of brown iron ores from the Trias formation, and of claybands and spherosiderites from the coal measures and the jura formation, the total output, in 1872, being 700,000 tons. The Trias limestone or "muschelkalk" around the towns of Beuthen and Tarnowitz is covered by a thick bed of dolomite, and it is generally at their meeting that vast beds and irregular deposits of a soft brown hydrate of iron are found, often mixed with zinc and lead ore, and at Tarnowitz and Naklo they are sometimes 10 to 12 fathoms thick. Their yield is seldom over 35 per cent. of iron, very often much less, and the zinc which they contain makes them rather awkward for smelting, and prohibits almost entirely the employment of closed furnace tops and the utilisation of the furnace gases, as the gas collectors and conveying pipes are liable to be choked by the zinc fumes. The Jurassic clay iron ores are found near Lublinitz, Rosenberg, and Creutzburg, and are very valuable, while the clayband seams of the coal measures are of little importance, and blackband seems to be entirely absent in the vast coal basin of Upper Silesia. Some good spherosiderites are also raised from beds of miocene clay and sand near Gleiwitz, Rybnik, and other places.

The Royal Iron Works of Gleiwitz, which own the oldest coke blast furnace of the continent, were founded in 1791, and have now two furnaces going, these producing annually nearly 10,000 tons of grey and white pig iron, while there are besides a large foundry and engine works. These works exhibited at Vienna together with samples of ores and iron, a very interesting graphic representation of the dimensions of their furnaces in 1799, 1829, 1854, and 1872, together with particulars of the daily consumption and yield. Of these data we subjoin an abstract.

—	1799.	1829.	1854.	1872.
Dimensions in Feet:	ft.	ft.	ft.	ft.
Height above tuyeres -	35·33	42	48	41·70
Diameter on top - -	3	4·40	6·15	12
„ at boshes -	11	10	15	17
„ at tuyeres -	3	2	3	8
Contents, cubic feet -	1,003	1,556	3,802	9,344
Daily Consumption:	cwts.	cwts.	cwts.	cwts.
Brown iron ore - - -	96	149	356	456
Clayband iron ore - -	60	79	74	740*
Limestone - - -	45	59	138	566
Coke - - -	40	140	306	846
Daily Production:				
Pig iron - - -	40	70	156	514

* In 1872, instead of clayband, 100 cwt. red iron ore, and 640 cwt. tap cinder were used.

From these figures it will be seen that the increase of the daily produce was solely obtained by enlarging the diameter and capacity of the furnaces, while increase of height had very little influence.

The next works we have to speak of are those of the United Kœnigs and Laurahütte Company, which was formed by amalgamating the former royal

works with those belonging to Count Henkel, and by converting them into a joint stock company. The Kœnigshütte, founded in 1798, now possesses seven blast furnaces and a large forge and rolling mill, the former having made in 1872, 59,500 tons of pig iron; while the Laurahütte, which was erected in 1838, contains eight blast furnaces, of which six produced 35,000 tons of pig iron in that year. There is another rail mill and forge at these works, and the company own also Bessemer steel works at Kœnigshütte, two large collieries, and a great number of iron mines, while they employ over 3,500 men. The quality of the Silesian forge pig is such that in the puddling furnace it comes slowly to nature, but it welds very readily, and the piles of puddled bars can be rolled out into a finished rail in one heat. As the works of Kœnigshütte were intended for model works by the Prussian Government, numbers of trials were instituted, in order to secure a good quality of the pig iron with an increase of the daily yield, and the prolongation of each campaign. In order to show what the furnaces once were and what they are now, we give in Figs. 11 and 12 sketches of sections through the tuyeres, and through the front and back walls of the Gerhard blast furnace, the fourth of the number such as it was blown in in 1818, and in Figs. 13 and 14, Plate XXVIII., a section and sectional plan of furnace No. 5 with six tuyeres, as it was in 1872 after the transformation of the Von der Heydt furnace. Figs. 7 to 18, Plate XXV., also represent the changes of the shape and dimensions which the Kœnigshütte furnaces have gradually undergone from 1796 until the new era, which had been entered upon under the able management of Inspector Eck, whose untimely death was much regretted. Regarding the history of the works, it may here suffice to say, that after the Reden furnace was blown in, in 1796, great difficulties arose from the nature of the ore and fuel and from the insufficiency of the blast, the first blowing machines being single-acting beam engines, which only furnished 1,700 cubic feet a minute. After the engine and blast power had been made greater, the Heinitz furnaces were started in 1802, Wedding in 1809, and Gerhard in 1818, but before 1827 they were never blowing all at the time for want of blast. Until 1830 only two tuyeres were used, but in that year a third was introduced in the back wall, and in 1835 hot blast from Calder heating stoves was first employed, the daily produce of each furnace being thus raised from 4 tons 12 cwts. to 5 tons 1 cwt. The following Table gives also an idea of the alterations made in these furnaces in the following years, 1829, 1855, 1865, and 1872 :—

——	1829.	1855.	1865.	1872.
	ft.	ft.	ft.	ft.
Height above tuyeres -	38·5	46	47	43
Diameter at top - - -	4	7	9	12
„ at boshes -	10·25	15	14·25	18
„ between tuyeres -	2·4	3	6·5	8·5
	cube ft.	cube ft.	cube ft.	cube ft.
Contents - - - -	1,519	4,476	6,600	7,490

These figures show that the capacity of the furnaces has been considerably enlarged, and that those built since 1848 have been increased in height, without, however, influencing the daily produce so much as had been expected. This was only attainable by widening of the furnace, and at the same time by increasing the quantity, temperature, and pressure of the blast, as the quantity of iron reduced will necessarily most depend on the quantity of fuel burnt in a given time. The iron ores became also rather poor; the Naklo brown iron ore fell off from 33 to 28 per cent., the average Tarnowitz ore from 27 to 20 per cent., while the clayband contains 30 to 32 per cent., and the forge cinder, which was only used in very small quantities for fear of spoiling the quality of the iron, 60 per cent. Thus the daily average

produce of one furnace was with cold blast in 1818 only 2·14 tons, in 1820, 2·7 tons, in 1827, 3·23 tons, in 1835, 4·6 tons, and with hot blast in 1835, 5·1 tons, in 1843 with poorer ores, only 4 tons, in 1847, 3·7 tons, and in 1852 again, 5·49 tons, while in 1854 in the new furnaces only 6 instead of the expected 7·5 tons was produced. At last, however, in 1871 an average yield of 27·3 tons was obtained, this being the consequence of hot, powerful, and abundant blast, and of the free use of rich tap and mill cinder with a proportionate addition of limestone, in order to counteract its injurious effects, while the furnaces of Laurahütte had in the same year an average daily produce of 18 tons.

The low yield of these Silesian blast furnaces is chiefly owing to the poor average yield of the burden, this, which was originally only 33 to 35 per cent., having fallen as low as 27 and 28 per cent., until recently rich cinder has been as we have mentioned freely introduced. The duration of the campaigns, however, had been well increased, as for instance, the Heynitz furnace, Fig. 28, had, in 1857, finished one of 11 years of uninterrupted blowing. The Kœnigshütte Iron Works had thus become a free school to the ironmasters and managers of Upper Silesia, a good number of whom have served their apprenticeship there.

The Borsigwerk Iron Works at Biskupitz, erected in 1863, belong to the engineering firm of A. Borsig, of Berlin, and they now possess four blast furnaces, which in 1872, produced 20,000 tons of manganiferous pig iron of high quality, while connected with these are large puddling works, and a Martin's steel works with three furnaces, as well as three collieries at the same place. The Redenhütte Iron Company own at Zabrze two blast furnaces, which in 1872 made 24,000 tons of pig iron and castings; they are of the English type, and provided with water cooling arrangements for the iron skin. The pig iron is mostly consumed by their own puddling works, where Danks furnaces are being adopted. The coking establishment, which is provided with coal from the Königin Louise Colliery, produces annually over 50,000 tons of excellent coke, made in coke ovens on the Appolt and Smet systems, while the iron mines of the company, near Tarnowitz, produced in 1872, 11,200 tons of iron ore, containing from 21 to 32 per cent. of iron, and 40 to 49 per cent. of silica; these, of course, caused a good deal of trouble in being smelted economically. The Hohenlohe Iron Works, which were started in 1806, and belong to the Duke of Ujest, contain four blast furnaces, which smelt the iron ore of the mines at Chorzow, Tarnowitz, and Georgenberg, and yielded in 1872, 15,000 tons, with coke made from coal of the Hohenlohe mine, and have an average daily produce of 16 to 18 tons. From the above observations it will be seen that the blast furnace industry of Upper Silesia labours under special difficulties, and that the cheap coal is almost its sole advantage.

We turn now to a country which, though it possesses rich iron ores in abundance, is almost entirely deficient of mineral fuel, while the little it has is at present not yet utilised in its iron industry. Sweden made nevertheless at the Vienna Exhibition an excellent show of her iron exhibits, and it is rather remarkable that from this country the first scientific essays on the art of iron smelting have emanated, although blast furnaces were first introduced there from the Lower Rhine, in the sixteenth century. Amongst the early treatises on iron metallurgy in the last century, we may mention Emanuel Swedenborg's Regnum Subterraneum, in 1734, Sven Rinman's essay of 1782, T. Bergman's, of 1783, and others, and there is no doubt that the progress of their country's iron industry has been greatly influenced by these authors. A still greater influence has, however, been exerted by the association of the Swedish ironmasters, the "Jern Kontor" or iron institute, which was founded in the early part of this century, in order to secure the interest of the trade commercially and scientifically, and to facilitate the introduction of improvements, by instituting trials on joint account, &c.; and it is an undeniable fact that Mr. Bessemer's now famous invention was saved only through the intervention of this Swedish institute from imminent danger of becoming an utter wreck. The first volume of the annals of the "Jern Kontor" appeared in 1818, and they have been continued to this present day. By the exertions

of the chemical laboratory, which is connected with the institute, almost all the iron ores and materials employed in ironmaking in Sweden, are well known through numerous analyses, and the geological features of the rich mineral deposits have been studied, and made known to the great advantage of the trade by the Mining School, which was formerly at Fahlun, and continues now at Stockholm, under the able direction of Professor V. Eggertz. We must not omit to mention here the beneficial influence of the Government Geological Survey upon the iron trade, this survey having been founded under the name of "Geological Office," under the superintendence of the late Professor Axel Erdmann, in 1856, and now continuing under the direction of the Arctic explorer and geologist, Otto Torell, with ten other active members, geologists, palæontologists, geographers, and chemists. Amongst these is Edward Erdmann, son of Axel Erdmann, who at the Vienna Exhibition very ably performed his task of bringing the geology of Sweden in a lucid manner before the general public, by exhibiting, in the name of the Geological Office, numerous geological maps, books, and samples of rocks and fossils.

Sweden produced, in 1871, 646,000 tons of iron ore from mines, and 56,000 tons of so-called lake or bog iron ore, or altogether 662,000 tons, this quantity being obtained by the labour of about 5,000 men, and by far the greatest quantities being raised in the counties of Kopparberg, Oerebro, Wermland, and Westmanland. The celebrated mines of the Dannemora district in Upsala county yielded 389,000 tons, those of Persberg and Yngshytta 622,000 tons, while the other most celebrated mines were worked at Taberg, in Jönköping, where a greenstone, containing over 30 per cent. of iron, and 6·3 per cent. of titanium and vanadium, constitutes a whole mountain; mines were also worked at Philipstad, in Wermland, Stripmine, Dalkarlsberg, and Striberg, in Oerobro, Risberg, Morberg, and Klackberg, in Westmanland, at Winkarn, Oern mine, Romme mine, great Bispberg, Bellingsberg, East and West Ormberg, and Slaed mine, in Kopparberg, and at Nyäng mines, in Gefleborg. Bog iron ore is only raised in the counties of Jönköping, Kronoberg, Kalmar, and Skaraborg, for the use of a number of blast furnaces only making foundry pig from it, this pig containing so much phosphorus, that it is unfit for being converted into malleable iron, and is therefore exclusively employed for the production of light castings, such as stoves, kitchen ranges, pots, saucepans, &c.

The iron ores of Sweden are either magnetic iron ore or specular iron ore and hematite, or a mixture of both, and they are principally found in metamorphic gneiss and in metamorphised or hardened Silurian slates generally connected with crystalline limestone or Swedish marble, and with dykes of trapp and other augitic porphyry. Their yield of metallic iron varies from 30 to 70 per cent., but the average may be taken at between 45 and 55 per cent.; they are generally deficient in manganese, some, however, such as those from Svarteberg mine, in Kopparberg, contain 10 to 15 per cent., and from Penning mine, in Gefleborg county, from 8 to 10 per cent., while the famous ore of Dannemora only holds 1·15 to 1·54 per cent., that of Persberg 0·15 to 0·46 per cent., of Klackberg 1·15 to 5·39 per cent., and of Langviksfaelt, in Garpenberg, 3·85 per cent. of that metal. It appears that manganese does not so much enter into the constitution of the iron ore itself, as that it belongs to other minerals, which are intimately mixed with the ore, such as knebellite, rhodonite, tephroïte, manganiferous garnet, and others. Some sulphur and often a little copper is contained in almost all magnetic ores, while most of them are practically free from phosphorus, that of Dannemora holding 0·003 per cent., of Persberg 0·004 to 0·005 per cent., while that of Great Bispberg contains 0·01 per cent., and only some otherwise rich ores from Gfangaerde and Gellivara come up to over 1 per cent., and 1·5 per cent., this being mostly due to a certain admixture of apatite or phosphate of lime. If such ores were to be got on the Continent, for instance in Silesia, they would be smelted with pleasure, and with a judicious admixture of other ores even make metal of first-rate quality, while in Sweden they are now not touched. The ores are hardly ever quite pure, but generally mixed with other minerals, as augite, hornblende, garnet, quartz, felspar, fluorspar,

calcspar, and others, and they often have such a composition, that for smelting they require no additional flux, as in the case of the Dannemora iron ore, while other cases by mixing several kinds of ore, all constituents for a good slag are also obtained.

In 1871 Sweden owned 292 blast furnaces, of which 207 made 299,000 tons of pig iron, thus giving for each furnace an average produce of 8 tons per day. The furnaces, of course, differ very much in their dimensions, having a height between 30 ft. and 53 ft., diameter at the top from 5 ft. to 6·5 ft., at the boshes from 7 ft. to 9·75 ft., width between the tuyeres from 2·8 ft. to 4·7 ft., and a capacity of from 900 to 3,300 cubic feet. They are blown generally with two, but sometimes with three or four tuyeres, while only the oldest and smallest furnaces have one. The blast is now almost exclusively produced by cylinder blowing machines, driven by water power, and its pressure varies between 0·35 lb. and 1·25 lb. per square inch; it is generally heated, but seldom up to 400 deg. Cels. (752 deg. Fahr.) The fuel is almost exclusively charcoal, made from pine and birch wood; only quite recently a few furnaces have used English coke mixed with it, or even alone. The difficulty of supplying sufficient fuel has been the cause for scattering the furnaces over the whole country, and with the exception of Finspong, which has two, all other iron works have only one blast furnace each. The daily production is with small furnaces from 4·3 to 7 tons, with middle sized ones from 7 to 12 tons, and with the largest from 12 to 18 tons of pig iron of excellent quality, with the exception of the foundry pig made from bog iron ore. By far the greatest quantity of the Swedish pig is converted into wrought iron in Lancashire and Walloon charcoal forges, and only in a few instances in puddling furnaces. The pig iron is generally produced as grey, but in a few instances, as at Hamarby, as white iron, while that from the furnaces which smelt Dannemora ore is always mottled. Only quite recently spiegeleisen has been produced at Schisshyttan, Finbo, Ferna, and Bernshammar, while the blast furnaces of Forsbacka and Mölnbacka exhibited at Vienna pigs of which the upper half was grey, and the lower half white and crystalline iron. The ore is always calcined, generally in kilns heated by the waste furnace gases, and this kind of preparation and the richness of the ore are the reasons for the comparatively large daily production. Amongst the exhibits at Vienna the collection made by the Jern Kontor, which was admirably arranged by Professor T. Hjortdahl, took the first place, and permitted a correct idea to be formed of the Swedish iron industry without the least trouble. In this collection were to be seen samples of ores, pig iron, and slags from the works of Kihlafors, near Söderhamn; Elfkarleö, near Gefle, which has existed since 1669; Forsmark, Wattholma, and Lenna, near Upsala; Forsbacka, near Gefle; Hammarby, Hofors, Avesta, and Garpenberg; Korsa, Löfsjö, Lima, and Laxsjö, near Stora Kopparberg; Nyhammar, in Dalarne; Wikmanshyttan, in Hedemora; Norn and Larsbo, near Kafalla; Bamnäs, Ferna, and Bernshammar, in Westeras; Riddarhyttan, near Gisslarbo; Kohlsoa; Hammarby, near Jerle; Degerfors, in Wermland; Storfors, near Christinehamn; Mölnbacka, near Kihl; Uddeholm, near Rada; and Nissafors, near Jönköping; Fagersta, near Westanfors, and Lesjöfors, near Philipstad, had separate exhibitions. The former smelts the ore from Norberg, the latter from Nersberg and Langbanshytta. The works of Laxa, Bofors, and Charlottenberg exhibited also the usual samples, while Schisshyttan, near Smedjebacken, had an excellent exhibit of spiegeleisen. This speciality was first made in Sweden at these works, by Mr. Alexander Keiller, Jun., in 1872, and it contains from 4 to 20 per cent. of manganese, while one analysis showed the following composition, viz., iron 75·100, manganese 20·350, carbon 3·800, silicium 0·254, sulphur 0·010, and phosphorus 0·029. White spiegeleisen from Finbo contained, iron 84·66, manganese 11·23, carbon 3·96, silicium 0·06, sulphur 0·02, and phosphorus 0·006 per cent. Works exhibiting specialities in castings which are mostly made direct from the blast furnace, such as chilled shot and shell and ordnance, were those of Ankarsrum and Finspong. The Ankarsrum Iron Works, near Westervik, have two blast furnaces, which smelt lake and bog iron ore, and from them all kinds of castings of

excellent quality are made in sand, loam, and coquilles; amongst the latter we noticed elongated chilled projectiles of 5 in., 8 in., 9 in., and 11 in. in diameter, made for Danish, Swedish, and Norwegian heavy ordnance.

The celebrated ironworks of Finspong, which were established in 1641, by a Dutchman, Louis de Geer, as a cannon foundry, possess two blast furnaces at Finspong and one at Sten, and until, in 1856, they became the property of C. Eckman, of Lesjöfors, one of the ablest metallurgists of our time, they were in possession of the De Geer family. The works have very good magnetic iron ore at their disposal, that from the mines of Förola, Nortorp, and Stenbo being particularly used in making cannon iron. Formerly the casting of the guns took place direct from the blast furnace; of late, however, the pig iron has been remelted in reverberatory furnaces after the method of the Lié Gun Foundry, so that a strong mottled iron is obtained. The breeches are generally still strengthened by being hooped with iron or steel rings. The works make 10,000 tons of pig iron and 7,500 tons of guns and projectiles.

The Scandinavian sister country made rather a poor show of her iron industry, as among the mineral exhibits we noticed only some good samples of magnetic and specular iron ore by John Petersen, T. J. Jahnsen, and D. Heiberg, of Bergen, and titanium iron ore by T. O. Feyer, of Stavanger, this latter ore containing from 52 to 64 per cent. of iron and from 14 to 28 per cent. of oxide of titanium. The production of iron, which once was very considerable, has, in consequence of the competition of coke iron, and the increasing dearness of charcoal, fallen off to about 8,000 tons of pig iron and to 4,000 tons of wrought iron per annum, made by 18 iron works of all kinds. The most important of these establishments are the Naes and Egeland Iron Works, near Arendal, belonging to Jacob Aall and Son, and possessing three blast furnaces, iron forges, and cast-steel works. The iron ores, which are smelted here with charcoal into grey and mottled pig iron of excellent quality, are obtained from the mines of Langsev and Solberg, near Arendal. At Langsev and at the adjoining Barbo mine a large rock of garnet is intimately mixed with augite, calcspar, and magnetic iron ore, and where the latter forms concentrations, which are sometimes 3 to 4 fathoms thick, and contain from 30 to 40 per cent. of iron, they are broken like in a quarry, and the annual quantity thus obtained is about 2,000 tons by only 12 or 15 workmen, while ten times that quantity could be raised with ease, if required. The Solberg mine produces a similar ore, being a mixture of magnetic iron ore, garnet, augite, and calcspar, and both ores are smelted without a flux, yielding an exceptionally pure and strong iron. This is converted into wrought iron in charcoal forges, the hammered bars are cemented and thus transformed into blister steel, which is broken up and remelted in pots or crucibles into cast steel. It is clear that in this way a first-rate kind of steel is obtained, though it is rather expensive. In former years the Naes bar iron was much sought for by the Sheffield steel makers, and almost exclusively sold to them. Jacob Aall and Son made a very complete show of their productions from the raw ore through all stages to ready steel ordnance, of which two six-pounder mountain guns and one eight-pounder and thirteen-pounder field guns were exhibited. The iron mines between Arendal and Kragerö, which not long ago produced 12,000 to 15,000 tons of excellent ore, are almost all deserted, as the iron works, which formerly used them, are lying cold; there are, however, such enormous riches of excellent iron ores left in them that an annual quantity of 50,000 tons could be easily raised for many years to come. The ores being generally mixed with other minerals, have only an average yield of 35 to 40 per cent., and could therefore not be exported with profit; but if they were collected in one hand, the erection of coke blast furnaces and Bessemer steel works, near Arendal, to be supplied with British mineral fuel, would be a highly promising enterprise.

The iron ore deposits of southern Norway have been very carefully explored by Professor Theodor Kjerulf and Bergmaster Tellef Dahll, who are at the head of the Government Geological Survey of Norway. These gentlemen, assisted by several younger geologists, have succeeded in hardly more

than 15 years in exploring geologically the greater part of their vast and thinly populated country, and in publishing the results of their researches in excellent colour-printed maps, comprising the provinces or stifts of Hamar, Christiana, Christiansand, Bergen, Trondhjem, and in numerous special maps. These were all shown at the Vienna Exhibition, accompanied by manuscript maps of Finmarken and Norland, the latter drawn by Charles Pettersen, of Tromsö.

We come now to review the exhibits of our metal in the departments of the Austro-Hungarian Empire, and begin our sketch of them with the provinces of Bohemia, Silesia, and Moravia, which produce one-third of all the pig iron made in Austria. This production was, in 1871, for the whole empire, 424,600 tons, of which 291,700 were made in Cisleithan Austria, and 132,900 in Hungary. And again in Austria proper the province of Bohemia produced 63,700, Silesia 5,900, and Moravia 30,000 tons, or all three together 99,600 tons of pig iron or castings, which were made direct from the blast furnaces. Regarding the history of the iron industry in these countries, we are able to give the following data :. Its age reaches back before our era, as even Ptolemy mentions in his geography that the tribe of the Quadi, who inhabited the province of Moravia, understood the art of making iron. The Bohemian chronicler, Hajek of Liboschan, mentions that iron works existed in 677, near Schasslau, where now those of Hedwigsthal and Hammerstadt are. In Moravia and Austrian Silesia, Buchbergsthal is named as the oldest iron works. Over the whole of that central part of Bohemia, which is covered by the Silurian formation, heaps of old iron slags are met with in numerous places, as well as the remnants of former ore bloomeries or wolf furnaces, while the names of many localities indicate that there once were forges and hammers. In 1807 Bohemia had 46 charcoal blast furnaces, which produced on an average daily about 23 or 24 cwt. of pig iron each. Iron works used formerly to be erected solely for the utilisation of the enormous forests in which the timber was rotting away without the possibility of drawing any benefit from them. Now, however, that good roads and railways traverse the country in all directions, the reason for the existence of many works has disappeared, and some are consequently laid cold, while there is a tendency to smelt the iron ores in blast furnaces with mineral fuel and to concentrate the works as far as possible. The first coke blast furnace was built in 1838, at Witkowitz, in Moravia ; next followed Kladno, in Bohemia, in 1854 ; Blansko, in Moravia, in 1857 ; Rossitz, in Moravia, in 1861 ; Prince Fürstenberg's works at Kœnigshof, in Bohemia, in 1871 ; and, in 1872, 13 new coke blast furnaces were being erected at Moravian-Ostrau, Witkowitz, and Trzienitz, in Moravia, and at Rokyzan and Kares, near Sbirow, in Bohemia. The best coking coals of Bohemia are those of Schwadowitz, Kladno, Lititz, and Müröschau, while those of Moravia and Austrian Silesia are also extremely well suited for the use of blast furnaces.

Regarding the iron ores of these provinces we may make here a few general remarks. They are connected with several geological formations. The metamorphic gneiss contains lodes of magnetic iron ore in the Erzgebirge and Fichtelgebirge, as well as red hematite and spherosiderite, while in the Sudeten mountains two extensive tracts of lodes, which contain magnetic, specular, and brown iron ore, are known to extend from Mohrau, in Silesia, over Bräunelstein, Bergstadt til Eisenberg ; sometimes these lodes are several fathoms thick. At Bräunelstein there is a bed of magnetic and specular iron ore, 3 ft. to 4 ft. thick, found in clay slate, and at Biskowitz one, 6 ft. thick, in crystalline slates. The silurian formation contains, in a belt 90 miles long and 23 to 40 miles wide, between Bischofteinitz, Pilsen, Beraun, Prague, and Schelakowitz, on the Elbe, very numerous and important iron deposits belonging to three distinct levels of the lower Silurian strata, and coming to the surface in many places. These deposits occur as rather irregular beds, from 1 to 10 fathoms thick, and dip at angles between 12 and 70 deg. Between Prague and Beraun extends a bed of fine-grained hematite with 50 per cent. of iron, over an area of 60 square miles, and it is accompanied by two overlying beds, which consist partly of an oolitic hematite, with 52 per cent. of iron, or of oolitic argillaceous red iron ore,

with 30 to 40 per cent. These deposits, particularly at Nuschic, belong to the richest of the province. Another series of three ore beds is known at Kruschnahora, where the lower bed is 5 fathoms to 6 fathoms, seldom 10 fathoms thick, the middle 1 fathom, and the upper seam half fathom. They are imbedded between greywacke and dioritic tuffae, and explored for 1,600 fathoms in length, and 120 fathoms in depth. Rich brown iron ores are also found in the same formation in irregular beds and pockets, for instance at Raschberg, Geissberg, Steklaberg, &c. The Devonian formation of Moravia contains a bed of magnetic, red, and brown iron ore, which is two fathoms thick at Bärn. It has been worked profitably for over 100 years, and is now being opened to a greater depth by new shafts, and the aid of steam engines. Clay-band ironstone is found in the coal measures at Buschtichrad, Raconitz, Radlowitz, and Brandeisl, in Bohemia, and seams of blackband occur at Michalkowitz and Peterswald, in Silesia. The Jurassic and lower Cretacean formations contain also ores between Brünn and Boskowitz, and at Trübau, in Moravia, while Tertiary iron ores are found near Wittinghau, Elbogen, and Falkenau, being spherosiderites and brown ore, with 20 to 30 per cent. of iron, and a considerable amount of manganese. Similar ores, with 18 to 28 per cent. of iron, 16 to 20 per cent. alumina, and 12 to 21 per cent. of lime, are known at Meseritsch, Mistek, Teschen, and other places connected with the Eocene and Upper Cretacean formations of the Carpathian system. The quantity of iron ores raised in these provinces by 4,000 men in 1870 was 333,000 tons.

We will now review the exhibits of the blast furnaces, of which, in 1870, four coke furnaces were blowing in Bohemia, and five in Moravia, making together 37,700 tons of iron, mostly forge pig, while 40 charcoal blast furnaces in Bohemia, 13 in Moravia, and 6 in Silesia, made together 61,700 tons, the greater part of the Moravian and Silesian furnaces employing from 20 to 60 per cent. of coke with the charcoal. The Prague Iron Industry Company owns at Kladno, near Prague, six blast furnaces smelting with coke, and two with charcoal. Two of the former are 48 ft., the others 52 ft., high, and produce on an average 14 to 15 tons a day. The coke furnaces are supplied with blast from two horizontal and one beam blowing engine, with a cylinder of 9 ft. diameter, and the same stroke. The total production in 1871–72 was 29,268 tons of pig iron, of which 21,763 tons were made in four coke furnaces, and 75,000 tons in the charcoal furnaces.

The collieries of the company near Kladno produced in the same year 434,000 tons, and the iron mines 39,000 tons. The rich beds of iron ore at Nuschic contain unfortunately a not inconsiderable amount of phosphorus, and the manager of the Kladno Iron Works, Director Jacobi, has, after many years' trials, so far succeeded in extracting it from the ore, before it goes to the furnace, that now one large blast furnace can be regularly supplied with purified ore. This chamoisite ore contains phosphorus in the state of phosphate of alumina, which is soluble in a solution of sulphureous acid, the latter being prepared by the calcination of iron pyrites, or by the reduction of sulphuric acid with charcoal. From the liquid thus obtained the phosphates are separated for the use of manure works, when it is fit to be employed again as a solving agent. The purification of the ores seems to be very successful as far as could be judged from the samples of cold-bent wrought iron which were exhibited at Vienna, and said to be made from the Nuschic ore. The company possess also four forges and rolling mills, which make 36,500 tons of rails, bars, boiler plates, &c., and they employ 8,500 workmen altogether.

Count Waldstein-Wartemburg exhibited pig iron and castings made at Sedlec in a blast furnace with charcoal, these being of very good quality, and showing a fine-grained fracture. The charcoal furnaces vary in Bohemia very much, the smallest being only 23 ft. high, and 5·5 ft. wide, while the largest, at Straschitz and Tranzensthal are 43 ft. high; most of the others, however, are below 40 ft.

The Erzebirge Iron and Steel Company, of Rokycan, near Komotau, showed iron ores, pig iron, and iron bars produced in a coke blast furnace, which was erected in 1872. The Witkowitz Iron Works of Baron Rothschild contain an old blast furnace of Belgian pattern (this having been, as we

have said, the first built in Austria), and two of English construction, with iron shell and independent hearth, these latter furnaces being 58 ft. high. The old furnace has a gas collector, and is blown with cold blast; while in connexion with the new furnaces are two horizontal twin blowing engines, two steam pumps, eighteen boilers and blast-heating stoves. The iron ores are magnetic and brown ore from Aussee, magnetic ore from Bennisch, red hematite from Moravian Neustadt, and brown iron ore from Tarnowitz, in Prussia. The average mixture contains about 33 per cent. of iron, and owing to the cold blast the fuel required per 1 ton of grey pig is about 2·8 tons of coke in the old furnace.

The Rossitz Mining Company, which we may next mention, own, besides their collieries (which produce 500,000 tons of coal), iron mines, and one coke blast furnace at Rossitz. The latter made 3,700 tons of forge pig in 1871, which was consumed by the rail mill of the company. The Blansko Iron Works of Prince Salm make grey foundry pig iron from two coke furnaces for the production of excellent castings for engineering and art purposes, and the exhibits at Vienna were admirable. Prince Fürstenberg's two coke blast furnaces at Koenigshof, near Beraun, were only built in 1870, but they may be considered as a good model for new Bohemian iron works, and the first of them, which was started in November, 1871, with ores from Nuschic and Krushna, makes 7,000 tons of grey foundry iron annually. The furnaces are 54 ft. high, 14 ft. wide at the top, 16 ft. at the boshes, and 5 ft. between the tuyeres, of which there are seven. The hearth is independent of the shaft, which is supported by eight iron columns.

The last iron works which we have to mention in these provinces are those of Archduke Albrecht, at Trzienitz, in Silesia, which contain two large coke blast furnaces, of which one is to make 14,000 tons of Bessemer, the other 16,000 tons of white forge pig iron. They receive the blast from three horizontal twin engines with twelve Henschel boilers 70 ft. length. The ores which they consume are principally spathic and brown iron ores with forge cinder, the former being derived from the Archduke's mines in Hungary of Bindt and Iglo, in Zips county and containing 45 to 53 per cent., from Fischiarka, Javor, Klesnova, and Zahutta, in Liptau county, with 32 to 56 per cent., and from Hlbaka and Troijka in Sohl county, with 55 to 56 per cent. All these ores contain some manganese, while the manganese ore of Dikula in Zips is also available for the mixture. The mining property comprises also numerous beds of clay ironstone and brown ore in Silesia, Moravia, Bohemia, and Galicia, which yield from 20 to 38 per cent. There are also six charcoal furnaces at Wegierska-Gorka, Baschka, Hradek, Obschar, Ustrom, and Carlshütte, which, in 1872, produced 7,100 tons of pig iron. At Carlshütte are steel puddling and Bessemer works, which utilise the very good steel pig iron, of which samples of spiegeleisen, made at Hradek, and exhibited at Vienna, contained 6·18 and 6·86 manganese, 2·57 and 3·98 carbon, 0·83 and 0·51 silicium, and 0·030 and 0·036 phosphorus, while a sample of dark grey Bessemer pig contained 2·34 manganese, 0·50 carbon, 3·35 graphite, 2·71 silicium, and 0·03 sulphur. It is evident, that from such raw materials first rate steel must be obtained.

We have next to notice the exhibits of Count Alexander Branicki from his iron works at Sucha, in Galicia, which, with one charcoal furnace, smelt the poor ores of the Carpathian mountains. Connected with these works are a foundry, several charcoal forges, and a rolling mill. Lastly, there are the iron works of Jacobenyi, in Bukowina, which were founded in 1784, and now belong to the Greek-Oriental Episcopate of the Bukowina. They own three charcoal blast furnaces, which in 1872 made 1,200 tons of pig iron, this being converted into wrought iron and castings at the forges of Csotina, Eisenau, and Freudenthal. The iron ores which are smelted are brown ore with 30 to 40 per cent., and clay ironstone with 18 to 21 per cent. from Fundul Moldawi, besides specular iron ore with 40 per cent. from a lode in mica shist at Jacobenyi. In all these provinces it is either the quality and quantity of the ores, or that of the fuel, which cause difficulties to the ironmasters, and trials have been made, therefore, of blast furnaces worked with raw coal and charcoal at Darowa, near Pilsen, as early as 1807, with peat at Gabrilenhütte in

the same year, and with raw wood in 1805, there, and later at Franzensthal; these trials, however, have not been attended by any marked success.

While the northern provinces of Austria are well provided with mineral fuel, but only indifferently with good and rich iron ores, the case is entirely different with her Southern and Alpine provinces, which abound in first-class iron ores, but are entirely limited to vegetable fuel, which becomes scarcer and dearer every year. The products of the iron industry in Austria Proper, Salzburgy Tyrol, Styria, Carinthia, and Carniola shine consequently through their superior quality, if compared with those of the north. The iron industry of the Alpine provinces was flourishing already before their conquest by the Romans, who had subjected the Celtic population of the Alps to their rule in the second century before our era—a rule which they upheld until they were in turn driven back again by the intruding Cambrians and Teutons after the loss of the battle of Noreja, in Styria, in 113 B.C. The "ferrum noricum" of Styria was celebrated all over Italy before that time, and the same ore deposits, the iron mountains or "ertzbergs" of Styria and Carinthia, which to this day supply the furnaces of these provinces with raw material, did so already 2,000 years ago.

The exhibition of the Styrian and Carinthian ironmasters, contained in two separate pavilions at Vienna, represented the progress in the manufacture of iron and steel in Styria from the most ancient times up to the present moment, and was of peculiar interest both from its completeness, and from the well known high quality of the Styrian iron. The basis for the iron industry in these districts consist in the rich and large bands of spathic ore distributed over the locality, intermixed with some red ore in the southern parts of the country. Charcoal was always used as fuel, and the vast forests of Styria and Carinthia yielded sufficient quantities for the purpose. The first knowledge of the Celtic and Roman iron smelting in these parts of Austria was afforded by the large mounds of slag which are found in the vicinity of the ore mines, and especially near Hüttenberg, close to the Carinthian Erzberg (ore mountain). Celtic and Roman implements and medals, including a coin of the Emperor Nerva (96 to 98 A.D.), have been found in these mounds, proving the antiquity of this iron industry. The first reliable statistical data, however, respecting the smelting of Hüttenberg spathic ore were found in several old documents of the eighth and ninth centuries.

In the year 1870 a most interesting discovery was made during the construction of the Hüttenberg Railway. In a cutting not far from the above-named place a set of iron melting hearths of Roman and Celtic times was found 6 ft. below the present surface of the ground. These hearths are represented in Fig. 1, Plate XXXII., from which it will be seen that they consist of two holes or ditches, R_1 R_2, the upper one, R_1, being supposed to have served as a calcining kiln, whilst the lower one, R_2, represents the smelting furnace proper.

These hearths were found near the mines of spathic ore in the neighbourhood of Hüttenberg. The calcining hearth is fitted with a layer of charcoal, *a a*, $1\frac{1}{2}$ in. thick, upon which a 10 in. layer of clay, *b b*, forms the inside lining of the hearth. This lining was found burnt by the action of the calcining fire to a depth of 4 in. The depth of the hearth is 2 ft., and its diameter 5 ft.

The second, or smelting hearth, R_2, is placed at a distance of 16 ft. from the former, and is 3 ft. deep and 4 ft. wide. The lining consists of a layer of 6 in. clay, *c c*, upon which a firebrick mass, consisting of clay and quartz, is uniformly spread to a thickness of 12 in. This lining is burnt and glazed to a depth of 3 in. at the inner side, thus recording the higher temperature in this hearth during the smelting operation.

Both hearths are filled with débris of burnt clay and slag, crumbled down from the walls of the hearths, which seem to have been raised 1 ft. above the surface of the ground. The space between the two hearths is paved with stones. The slag was deposited at H_1, and contains many unburnt pieces of charcoal. The analysis of the slag has proved that the yield of the spathic ore in use, containing from 50 to 60 per cent. of iron, was only 15 to 20 per

cent. The blast seems to have been furnished by bellows from the top of the furnaces. A Roman cornice has been found near the smelting hearth.

These discoveries point out a very primitive process as compared with our present means of iron smelting; but centuries vanished before any real improvements were introduced. Nevertheless we find that the preparatory calcination of the ore previous to its being introduced in the smelting furnace is a very ancient mode of economising labour and fuel.

The next amelioration in the iron smelting process was inaugurated by the introduction of blast furnaces in the eighth century. These furnaces (see Fig. 2, Plate XXXII.), had a diameter of from 3 ft. to 4 ft. and were from 5 ft. to 6 ft. high. They were placed near the ore mines of the country, and erected in such positions on the mountain ridges as to be subject to a constant draught. The inside of these stoves was lined with fireclay, and the bottom was concave, so as to receive the iron bloom, which was removed through an opening made in the front of the furnace. The first of these stoves were not worked with blast, but an underground channel or flue, ending below the furnace and opening on the mountain side, was thought sufficient to create the necessary draught. After the introduction of bellows, the blast was delivered to the fire by clay tuyeres projecting as far as possible in the inside of the hearth.

The furnace having been filled with ore and charcoal, and the fire lit, the bellows was turned on and the whole mass well mixed together. The operation lasted from 10 to 12 hours, when a bloom of 2 to 3 cwt., mixed with slag and coal, was produced and extracted. The yield was from 25 to 30 per cent. out of the iron ore, which shows a progress of 10 per cent. as compared with the first method.

The introduction of water wheels, and the necessity of using blast at a higher pressure to obtain a larger yield in a specified time, soon obliged the owners of iron furnaces, to change the site of their smelting places and to transfer them to the vicinity of water power. The dimensions of the furnaces were enlarged and the bellows worked by water wheels. These furnaces were commonly called "Wolff furnaces," and had a rectangular base 4 ft. or 5 ft. by 3 ft. and a height of from 6 ft. to 8 ft. After the 16th century the base was changed into an elliptical or circular form, and in the 18th century these furnaces very much resembled the oldest types of high blast furnaces.

Fig. 3 shows the section of a Wolff furnace at Sölling, in Carinthia, dating from the year 1775. A breast opening in the front of the furnace was provided for the removal of the iron bloom at the end of the operation. This breast opening, 2 ft. square, was closed with clay when the blast was on. At the opposite side of the furnace a slot 5 in. wide and 2 ft. high allowed the slag accumulating in the furnace to run out, this slot being closed with clay according to the increasing level of the molten iron inside the furnace. The blast tuyeres passed through the breast opening; and from time to time they were set in a higher level as the rising iron necessitated their removal. The operation lasted from 19 to 20 hours, and yielded a bloom of from 12 to 15 cwt.

Puddle iron or steel was manufactured in these furnaces, according to the demand, by changing the inclination of the tuyeres. The annual production of a Wolff furnace amounted to about 150 tons. The cost of production for half a ton of iron was as follows:—

	£	s.	d.
Ore 1 ton 11½ cwt.	0	16	1
Charcoal, 450 cubic feet	1	4	0
Labour	0	0	10
Freight and divers expenses	0	3	5
Repairs	0	2	3
Duty	0	2	10
Total	2	9	5

Cost of one ton of iron 4*l.* 18*s.* 10*d.*

The blast was provided by two common bellows worked by water wheels. The bellows were 8 ft. long and 3¾ ft. broad. They supplied 240 cubic feet of air per minute.

There were generally two of the above-mentioned furnaces at an iron works, these going alternately, and requiring four smelters. Their annual production was about 100 tons of "rough iron," as it was called. Some of these works contained also a forge, where the rough iron was reheated and hammered out into bars. Such works were called "German hammers," and the owners, to distinguish them from those of air furnaces "wheelmasters," because they employed water power. They required six smiths and assistant for the forging of the "wolves," which came from the furnaces, these "wolves" having a weight of 8 cwt. to 12 cwt., and having to be broken up while hot before going to the forge. At the end of the 16th century there existed in Carinthia still 23 iron works with wolf furnaces alone, and 11 German hammers.

Blast furnaces were introduced in the Alps very much later than on the Rhine, in Thuringia, and in Belgium, the first in Carinthia being built in the second half of the 16th century, about 1567, at Urtl, near Guttaring, belonging to the town of St. Veit, while the first blast furnace of Styria was erected, in 1760, at Eisenerz, and in Carniola only in the beginning of the present century. The earlier furnaces were 15 ft. high and had square sections, 18 in. at the top, 3 ft. at the boshes, and 24 in. at the bottom. A chimney was placed on the top of them, 15 or 18 ft. high, to increase the draught. Fig. 4, Plate XXXII., shows the section of a blast furnace erected in 1768 at Mosinz, in Carinthia. These furnaces were in blast at the utmost during 15 weeks, when they were taken into repair. The production was about two tons per day, and the actual cost of the pigs obtained averaged 3*l.* 10*s.* per ton. At the end of the 18th century the dimensions of the furnaces were increased, and their production in consequence increased up to the present time. The largest blast furnaces for charcoal pig iron now in blast are at Vordernberg, in Styria, and reach a production of about 35 tons per day. The sections, Figs. 5 to 9, on Plate XXXII., show the different types of blast furnaces in use in Carinthia from the beginning of the present century, and give an excellent illustration to the statement made at the beginning of this section concerning the constant increase in the quantities dealt with in the metallurgical processes.

In 1650 there existed only four furnaces, and in 1759 but nine in Carinthia. They were originally 15 ft. high, 3 ft. wide at the boshes, 1·5 ft. at the top, and made 30 to 35 cwt. of "flowing" pig iron daily, each campaign lasting 10 to 20 weeks. Not until 1802 were furnaces which had a height of 32 ft. built at Treibach, in Carinthia, and Eisenerz, in Styria, these being provided with two or three tuyeres and receiving their blast from square wooden box blowing machines with movable pistons, instead of from wooden bellows. The first iron cylinder blowing machine was put up at Treibach, in 1820; it had been made at Mariazell. Thus the production of the furnaces had been gradually increasing, while the small blast furnaces, at the beginning of this century, made 700 to 1,000 tons of pig iron, and the larger furnaces with hot blast 1,500 to 2,000 tons. The largest blast furnaces at Vardenberg, 42 ft. high, and worked with blast at a temperature of from 570° to 750° Fahr. now produce 7,000 to 10,000 tons of white and mottled pig iron annually, and only consume 60 to 70 lb. of charcoal in making 100 lb. of iron. Hot blast was first introduced at Jenbach, in Tyrol, in 1835; then at Turrach, in Styria, Eberstein, in Carinthia, and Hof, in Carniola. The first coke blast furnace of the Alpine provinces was started, in 1870, at Prävali, in Carinthia, and new furnaces were built at Niklasdorf, near Leoben, and Zeltweg, near Knittelfeld, in 1872. The produce in 1851 was with 77 blast furnaces 90,000 tons, in 1861 with 72 furnaces 127,000 tons, and in 1871 with 62 only 195,000 tons of pig iron, of which quantity Carinthia made with 17 furnaces 63,000 tons, and Styria with 31 furnaces 122,000 tons.

Fuel has ever been one of the principal agents in metallurgical processes, and nowhere has its quality been of more importance than in the manufacture of pig iron. In Austria, charcoal, as the oldest and most readily obtainable

fuel, was the only material used in blast furnaces up to a recent period, when the yield of the forests began to decrease, and the enlarged demand for pig iron, wrought iron, and steel necessitated the use of fuel of a less costly nature and less limited in quantity.

The exhibits in the Vienna Industrial Palace proved the well-known fact that, as the devastation of the woods took place, and the necessity of increasing the yield of furnaces was felt, coke was substituted as fuel. This change necessitated alterations in the form and dimensions of the blast furnaces, as well as in the general working, to suit the special qualities of the new smelting material.

The introduction of coke as fuel in the iron manufacture on a large scale nearly coincides with the general introduction of steam navigation and railways, steamship owners and railway companies being the principal and most regular customers of ironmasters. We find, for instance, the production of iron to have increased in Prussia at the following rate:—

				tons.
Production of iron ore	in the year	1837	- -	240,000
„	„	1871	- -	2,900,000
„ coal	„	1837	- -	2,000,000
„	„	1871	- -	26,000,000
„ pig iron	„	1837	- -	100,000
„	„	1871	- -	1,200,000

In the province of Silesia the increase was nearly the same:—

	1837. tons.	1872. tons.
Production of iron ore - - -	90,000	722,000
„ pig iron - - -	31,000	315,000

In Carinthia we find the production of pig iron:—

	tons.
In the year 1822 to be - - - -	13,380
„ 1837 „ - - - -	19,300
„ 1871 „ - - - -	66,700

These figures speak for themselves, and the rapid increase in the demand for pig iron necessitated the introduction of coke furnaces, even at the risk of deteriorating the quality of the manufactured products. Indeed we found in the Exhibition that even in the Austrian Alpine iron districts (the principal charcoal iron countries of the Continent), coke blast furnaces have lately been erected in close vicinity of the older charcoal furnaces. The iron produced in these coke furnaces is, according to the statements of all concerned in the trade, of equal excellence to that manufactured in the old charcoal furnaces.

We find the same circumstances in the German districts where ironmasters long ago abandoned the use of charcoal, owing to its exorbitant price and to the impossibility of increasing the quantities to be had. Even in Siegen, and in the Ruhr district, where nearly all the ore is transformed into spiegeleisen of the best quality, charcoal smelting is now nearly unknown. The introduction of coke furnaces has aroused many doubts in the minds of iron merchants as to the advisability of such a proceeding, as not only was a deterioration of the far-famed quality of Styrian and Carinthian iron thought to be the result, but also the prestige of these districts was feared to be jeopardised. These fears have, however, proved groundless.

Great mistakes have been made in these matters, as many a district deficient in charcoal, could have gained great wealth by the early introduction of coke furnaces instead of carrying on a languishing business by sticking to antiquated traditions, these forming an insurmountable barrier against the increase of production and the reduction of the cost of the manufactured pigs. An extensive experience in these matters has shown that purity of the ores used is the principal object to be aimed at if a good quality

of iron is desired, and that in consequence of the advancement made in purifying and in the manufacture of coke, as well as with our present means of transport, it is always possible to procure coke of such purity, that in most cases it may be regarded as a perfect substitute for charcoal. Impurities in ores, on the contrary, can only be eliminated in rare cases. We also must bear in mind that the prices of charcoal have reached an immense height, and that for a much lower price than that now paid for charcoal almost everywhere, first-rate coke can be obtained in unlimited quantities.

To prove this we need only give the prices of charcoal as at present paid in Styria and Carinthia. One cubic foot of fir-wood charcoal now fetches about $3\frac{1}{2}d.$, and 1 cubic foot of beech charcoal is sold at about $6\frac{1}{2}d.$ Of the former about 300 cubic feet are wanted to melt one ton of grey Bessemer pigs, and 240 cubic feet to produce one ton of white forge iron, or, say, the fuel to produce one ton of Bessemer pigs costs about 87*s.* 6*d.*, and the fuel necessary for the manufacture of one ton of white forge iron is worth 70*s.*

We must bear in mind that these figures represent average prices, and that under some circumstances the price of charcoal rises more than 15 per cent. The higher price of beech charcoal has not been taken into consideration, owing to the very small quantities which can be had in Styria.

In full accordance to what we have stated in the preceding paragraphs, we always find those marks of pig iron to be the best which are manufactured in districts where pure ores are found, quite irrespective of the fuel used in smelting. The Siegen spiegeleisen, for instance, made in coke furnaces, as well as Swedish and a great part of Styrian and Carinthian iron, the latter manufactured in charcoal furnaces, are made from ores of the very best description, and free from all endangering impurities. The brands of iron produced from these ores are well known for their excellence, whereas many charcoal furnaces are to be found producing pig iron of very inferior quality, though, with exception of the ores used, all other conditions are identical with those met with in Styrian iron works manufacturing first-class Bessemer pigs.

TABLE No. I.—Analyses of Ores, &c., used in the Blast Furnaces at Finnbo.

Constituents.	Calcined Ore from Marnäs. Analysed by T. Wiborg.	Uncalcined Ore from Hillång. Analysed by C. Amark.	Limestone as Flux. Analysed by M. Nisser.	Slag Produced. Analysed by T. Wiborg.
	1870.	1872.	1873.	1870.
Magnetic iron	60·75	52·30	—	—
Protoxide of iron	—	—	—	1·25
Sesquioxide of iron	—	—	3·35	—
Protoxide of manganese	—	13·95	—	20·55
Sesquioxide of manganese	21·50	—	0·70	—
Lime	3·30	7·35	85·00	28·75
Magnesia	2·90	2·00	0·60	1·70
Alumina	1·00	2·25	—	7·75
Silica	9·70	16·70	10·40	38·15
Carbonic acid	—	5·40	—	—
Sulphur	0·18	0·04	trace.	—
Phosphorus	—	0·01	0·009	—
Sulphuret of lime	—	—	—	1·80

Some analyses of ores and pig iron exhibited in the Vienna Exhibition will corroborate this statement. The blast furnace at Finnbo, belonging to Count

Hermansson, produced excellent spiegeleisen, which has been analysed by Mr. T. Wiborg as follows :

Iron	84·66
Manganese	11·23
Copper	0·06
Silica	0·06
Phosphorus	0·006
Sulphur	0·02
Carbon	3·92
Total	99·956

This spiegeleisen was obtained from a mixture of 62 parts of ores from Marnäs, of 18 parts of ores from Hilläng, and 20. parts of limestone, the whole smelted in a furnace with two tuyeres and a blast heated to 215 deg. Celsius. As fuel, charcoal was used mixed with one sixth of its weight of coke. The principal dimensions of the furnace are given in the Table No. V. on page 50, while Table No. I., on the preceding page, gives the analyses of these three varieties of ores and of the slag produced.

TABLE No. II.—Analyses of Ores and Flux used at Fagersta and Westanfors.

Constituents.	Iron Ore from the Mines of			Limestone from Hedkärra.
	Ostra Stortägten.	Granrot.	Gröndal.	
Silica	27·49	3·10	6·35	10·82
Alumina	1·30	2·05	1·15	7·15
Lime	2·16	1·20	2·65	36·61
Magnesia	1·76	1·05	3·85	6·86
Protoxide of manganese	0·81	10·40	5·50	1·25
Protoxide of iron	20·74	23·56	22·82	—
Sesquioxide of iron	46·14	52·44	50·78	—
Carbonic acid	—	6·10	5·95	37·18
Phosphoric acid	0·016	0·009	0·014	0·007
	100·416	99·909	99·064	99·877

At the well-known iron and steel-works at Fagersta and Westanfors, in Sweden, the ores and flux used for the production of first class Bessemer pig-iron give on analysis the results recorded in Table No. II., above, while the average chemical composition of these iron ores, with the limestone added as flux, is as follows :

Silica	11·93
Alumina	2·53
Lime	7·51
Magnesia	2·76
Protoxide of manganese	5·63
Protoxide of iron	19·76
Sesquioxide of iron	48·89
Carbonic acid	6·02
Phosphoric acid	0·013
Total	100·013

Such a charge yields, in smelting, from 48 to 50 per cent. of pig iron, which is tapped directly into the converter, and consists, on an average, of the following parts :

Carbon combined	3·460
Graphite	1·289
Manganese	4·491
Silicon	0·771
Phosphorus	0·027
Sulphur	trace

The blast furnace slag contains :

Silica	41·96
Alumina	7·02
Lime	25·04
Magnesia	17·75
Protoxide of manganese	6·57
Protoxide of iron	0·23

The excellent quality of iron produced at Fagersta is not only due to the use of charcoal as fuel, but principally to the excellence and purity of the ores employed, which, if smelted with good coke free from sulphur and other impurities, would produce nearly, or quite, the identical sort of iron.

We can give a striking example of the influence which nearly unobservable alterations in the constituents of iron ores used in blast furnaces exercise upon the quality of the manufactured pig iron.

At the well known iron and steel works at Neuberg, in Styria, where the manufacture of the very best sort of pig iron and steel is the object aimed at, the ores used in the charcoal blast furnaces (represented in Figs. 10 and 11 on Plate XXXII.) are taken from a mine at a place called Altenberg, five miles distant from the furnaces, and yielding an excellent quality of spathic ore. The analysis of this ore is shown in the following table No. III.

Near this mine, and not more than a few hundred feet distant, a second band of spathic ore has been discovered, and, owing to the facility of exploration, this mine, called Bohnkogel, has been opened and worked a few years ago. The analysis of the Bohnkogel ore is given in the second column of the following Table No. III. :—

TABLE No. III.—Analyses of Altenberg and Bohnkogel Ores.

Constituents.	Analysed by the Imperial Laboratory in 1867.	
	Calcined ores from Altenberg.	Calcined ores from Bohnkogel.
Protoxide of iron	4·69	2·72
Sesquioxide of iron	67·22	72·25
Protoxide of manganese Sesquioxide of manganese	3·36	3·20
Alumina	2·49	1·50
Lime	1·25	1·10
Magnesia	4·11	5·71
Silica	12·49	11·73
Carbonic acid	3·35	1·50
Phosphoric acid	trace	trace
Sulphuric acid	0·49	0·61
Organic matter, copper, &c.	0·07	0·18

As may be seen by comparing the two columns of the preceding Table No. III., the difference in the constitution of the ores from Altenberg and those from Bohnkogel seems at first sight to be most unimportant, and of no

influence upon the quality of the iron produced. Yet this trifling difference is quite sufficient to produce very striking alterations in the quality of the manufactured pig iron. The Altenberg ores alone with 20 per cent. of limestone as flux, give the very best quality of Bessemer pig iron obtainable, this iron being used in the converters without the addition of any spiegeleisen for the production of the renowned Neuberg-Bessemer steel, which is superior to any steel that is made on the continent; whereas the pig iron produced from Bohnkogel ores in the same furnace, with the addition of the same limestone as flux, and with the same mode of smelting, has given very unsatisfactory results, and, indeed, necessitated the stoppage of the smelting with Bohnkogel ores after a few months' trial. The wrought iron manufactured from these pigs was red short, and the Bessemer steel was deficient in tenacity, and could hardly be used for the purposes where Neuberg steel is wanted. After some time it was found out that Bohnkogel ores could only be used in the blast furnaces when they were added to the Altenberg ores in the proportion of one to five.

On the other hand, trials which were made at Neuberg in the same blast furnace, but with Altenberg ores alone, have proved that 20 per cent. of the fuel could be replaced by coke without interfering in the least with the quality of the iron produced, though the coke was of inferior quality, giving 18 per cent. of ashes, these being composed, on an average, of the following parts (the analysis was made by the Imperial Laboratory, 1871):—

Silica	47·0
Alumina	38·1
Lime	8·0
Phosphoric acid	0·5
Copper	trace
Magnesia	3·0
Protoxide of manganese	0·9
Sulphuric acid	0·9

There can be no doubt that, as even coke of so unsatisfactory composition has proved to have little influence upon the quality of the iron when added to the above-named amount, everywhere coke may be got of sufficient purity to be used as substitute of charcoal without endangering the quality of the products, and with a reduction of the present cost of manufacture, as has been done with perfect success in the Siegen district.

For these reasons the introduction of coke blast furnaces must be looked upon as a welcome improvement in the iron industry, so much the more as the cost of making charcoal iron has reached such a limit that profits will become fictions when market prices fall.

We give in Table IV. an abstract of the cost of manufacture of one ton of Styrian or Carinthian charcoal iron, the prices being deduced from the results of different iron works of the country.

TABLE No. IV.—Showing Cost of Producing one Ton of Charcoal Iron in Styria or Carinthia.

	Grey Bessemer pig iron. Best quality.			White puddle iron. Best quality.		
	£	*s.*	*d.*	£	*s.*	*d.*
Calcined ores containing about 48 to 50 per cent. of iron.	2	1	0	2	1	0
Limestone as flux	0	1	7	0	1	7
Charcoal	4	7	6	3	10	0
Labour	0	10	2	0	6	8
Different outlays, materials, &c.	0	4	7	0	2	9
Administration	0	2	11	0	1	2
Total cost of one ton of iron	7	9	7	6	4	9

Since the introduction of blast furnaces, not only the question of fuel, but also that of the best form of the furnaces, has given rise to continual discrepancies in the opinions of mining and metallurgical engineers. Every now and then trifling and minute alterations in the inside form of blast furnaces have been made by engineers, who, by most ingenious calculations, and physical researches, have thought to obtain some fictitious advantages by raising or lowering the boshes several inches, or by giving the sides of the furnace special curvature, &c. And often beneficial results, simply due to the general form of the furnace, or to the materials employed, as well as to the mode of carrying on the operations, have been attributed to these scientific meditations.

TABLE No. V.—Dimensions of Blast Furnaces.

DESCRIPTION OF FURNACE.	Number of tuyeres.	Height of furnaces.	Diameter between			Capacity of Furnace.	Yield per Week.	Remarks.
			Tuyeres	Boshes.	Top.			
Year of erection.		metres.	metres.	metres.	metres.	cub. metres.	tons.	
Gleiwitz, 1854, coke furnace.	3	15·58	0·94	4·70	1·88	117·58	56·25	Open breast.
Gleiwitz, 1872, coke furnace.	8	13·7	2·56	5·34	4·00	220·7	250·	Closed hearth and top.
Königshütte, 1855, coke furnace.	3	14·4	1·07	4·7	2·2	138·1	...	
Königshütte, 1865, coke furnace.	7	14·8	2·5	4·7	3·14	204	..	Open hearth.
Königshütte, 1872, coke furnace.	8	13·5	2·67	5·65	3·77	231·6	..	Closed hearth.
Creusot, coke furnace -	3	16·80	1·40	5·00	3·00	158·7	175·	
Heinrichshütte, 1861, coke furnace.	3	15·00	1·10	4·10	2·51	..	..	
Bessège, coke furnace -	3	14·10	1·00	3·96	2·00	..	112·	
Wittkowitz, Moravie, coke furnace -	7	18·72	2·24	5·44	{3·20 / 4·80}	..	..	
Prävali, Carinthia, 1872 -	6	16·96	1·93	4·68	2·88	..	240·	
Gleiwitz, charcoal, 1799 -	..	11·18	0·90	3·45	0·96	40·31	13·7	Open hearth.
„ „ 1829 -	2	13·14	0·63	3·14	1·36	48·14	25·	„
Königshütte," charcoal, 1828.	2	12·11	0·76	3·22	1·25	46·9	..	„
Bogsbau, Hungaria, charcoal.	4	13·3	1·00	2·85	2·02	56·5	100·	
St. Gotraud, Carinthia, 1872.	3	11·20	1·16	2·56	1·11	..	46·	Charcoal furnace.
Waldenstein, Carinthia, 1872.	3	9·98	0·85	2·56	0·95	..	39·	„
Combiers, charcoal, France	2	8·79	0·63	2·05	0·62	..	17·5	Open hearth.
Friedau „ Styria	..	13·27	1·89	2·26	0·79	..	161·	
Trummelsberg, Sweden -	2	13·06	1·36	2·82	1·78	..	67½	Charcoal furnace.
Björnhittan „ -	2	12·76	1·17	2·67	1·45	..	31·	„
Finnbo „ -	2	11·87	0·94	2·37	1·39	..	24·	„
Straczena, Hungary -	..	9·28	0·72	2·56	0·85	..	..	Charcoal.

We give in the above Table No. V. some of the principal dimensions of blast furnaces, as exhibited in the International Exhibition at Vienna, to show that not even in these really important measurements can the least coincidence of opinions be found.

This table gives good evidence that no general rules have up to the present time been deduced for the best form of blast furnaces under certain conditions, as not even those furnaces which are in close vicinity to each other, and which are worked under similar conditions, have been built with corresponding dimensions.

This fact will be understood easily enough when we say that only the original designs for the construction of a blast furnace to be erected at a certain place happen to be brought to the knowledge of metallurgical engineers; but never, or very seldom only, are the results and experience gained in working this furnace brought before the public. This want of general

rules becomes the more striking when we find that nature itself has made the best engineer and draughtsman in this case, and that we only want to keep our eyes open to its teachings. Ambition and selfishness alone can have kept us so long from acknowledging these facts.

It is clear that the best form of blast furnaces will be that which, all other circumstances being equal, will work with the greatest economy of fuel, and with the least deterioration of the furnace lining. Now instead of engaging ourselves with extended speculations about the mode of finding out the best form of furnaces, it would prove to be much wiser to look at the inside of such furnaces after they have worked effectively for some time. It is by no means a rare fact that blast furnaces give the best working results a very short time before they are obliged to be put out of use on account of the general wear and tear of the lining.

In all such cases the furnace itself, at the end of a campaign, will give valuable hints as to the form best adapted for the particular circumstances. But instead of learning by close inspection the wants of nature, in most cases we rebuild the furnace according to the original type, quite irrespective of the conclusions which may be drawn from the excessive deterioration of some parts of the interior.

It is more than probable that the comparison of a series of such *self-formed* sections of blast furnaces at the end of their campaigns will afford us means of deducing certain formula for the determination of the most effective form of coke or charcoal blast furnaces, with due reference to the different circumstances under which they may work. But to arrive to such a desirable result, it is necessary before all that the different ironmasters and metallurgical engineers should aid the undertaking, by publishing the results obtained with furnaces of certain construction, and at the end of each campaign give a complete section showing the wear and tear of the lining.

An instance of this kind is illustrated by Figs. 12 to 18, Plate XXXII., which show the section of a charcoal blast furnace in its original form, and after a very successful uninterrupted campaign of five years' duration, its ultimate shape being shown by the dotted lines. The furnace was very minutely inspected after having been put out of blast, and all the inside dimensions were taken with the greatest care. The furnace was lined with bricks, and the crucible was constructed of refractory sandstone. This furnace is one of a set of three, at the well-known works at Mariazell, in Styria, where it was melting calcined spathic ores containing 42 per cent. of iron, with a consumption of 12 cubic feet of fir charcoal per 100 lb. of iron. The furnace was working in the most effective manner at the end of the campaign, a few weeks before the blast was shut off, which was only necessitated by part of the brick lining having fallen down, owing to the great reduction in thickness of the latter. (See Figs. 13, 17, and 18.)

But the most interesting feature in this case is the striking resemblance of the deteriorated section of the Mariazell furnace with the form adopted in some parts of Styria, and looked upon as the best adapted to smelt spathic ore under the conditions in which they are used. The dimensions of the type of these last-named furnaces are represented on Plate XXXIII., the view there given being a section of charcoal blast furnace at Hieftau, near Eisenerz, Styria.

We also give on Plate XXXIII. sections of another of the furnaces at the Mariazell works, these sections having been supplied by Mr. Josef von Stummer-Traunfels. The furnace shown in the sketches is the third of the three charcoal furnaces at work at the Mariazell Iron Works, producing very strong grey foundry iron run directly from the blast furnace into the moulds. The furnace was working very satisfactorily to the moment of its being put out of blast, which only was occasioned by the long period the furnace had worked continually (over three years), and which, according to the results obtained at the place, would have necessitated sooner or later the stoppage of the furnace. But it would have been kept in force for some time longer, owing to its good results, had not a momentary want of fuel, which did not allow of the working of three furnaces, accelerated the decision of the very able manager of the works, Mr. Joseph von Rutner, to stop it for

re-lining. The dotted lines show the section after the campaign, which, as we have stated, was a very successful one, as well for the quality of the iron produced, as for the economy of fuel, showing that the section of the furnace, as made by nature, was quite adapted to the work.

After this historical sketch and digression concerning the forms of blast furnaces, we may next glance rapidly at the iron mines and their ores upon which the whole iron industry of Austria rests. The products of these mines are almost exclusively spathic iron ore and brown iron ore, which through oxidation and absorption of water, had originated from the former. They contain, on an average, in the raw state, 40 per cent., and calcined, 50 per cent. of iron, besides 2 to 3 per cent. of manganese, and 3 to 4 per cent. of magnesia, while they are almost entirely free from phosphorus. In former times only the oxidised carbonates were smelted, while now the undecomposed carbonates and the brown ore go together. Clay ironstone and bean iron ore are found and smelted in Carniola, where they belong to the Triassic formation. The greater part of the ores, however, belongs to the Silurian and the Lower coal period. They are arranged in three tracts of ore beds. The northern tract begins at Schwaz, in Tyrol, and extends through Salzburg, Upper Styria, over the Semmering into Lower Austria, bearing east, a distance of nearly 200 miles; it contains valuable mines at forty or fifty places, these mines supplying 37 or 38 blast furnaces with ore. The largest of these mines is the ertzberg of Eisenerz. The southern tract of ore beds runs nearly parallel to the former from Kremsbrücken, in Carinthia, to Turrach, Fladnitz, Friesach, Weitschach, Hüttenberg, and Waldenstein, including the Carinthian ertzberg. It is over 70 miles long, and feeds 18 furnaces in Carinthia, and one each in Styria and Salzburg. The third tract, 20 miles long, stretches from Sava over Jauerburg, Selenitza to Neumarktl, in Carniola, and belongs to the Triassic limestone, supplying two furnaces at Sava and Jauerburg. The quantity of iron ore produced in 1851 was 296,000 tons; in 1861, 352,000 tons; and in 1871, 571,000 tons; of this latter quantity 376,800 tons were raised in Styria, and in Carinthia, 162,600 tons. The iron mountain of Eisenerz produced during late years over 175,000 tons annually, mostly from open cast mines, and is estimated to contain at least 150 million of tons, while the ertzberg of Hüttenberg produces annually over 100,000 tons from underground workings, and is stated to hold, as far as the researches go, over 162 millions of tons. The ores contain raw 40 to 42 per cent., and calcined, 48 to 52 per cent. of iron.

Next to these there are other good iron mines at Veitsch, Turrach, and Lietzen in Styria, Sava in Carniola, Edlach in Lower Austria, and at Schwaderer, Gebra, Launer, and Schwaz, in Tyrol. The greatest iron producer in these countries is the Innerberg Principal Company, who showed its exhibits in a special pavilion at Vienna. The property consists of over 200,000 acres of forests, and a number of large mines, amongst which is the iron mountain, that in 1872 produced 250,000 tons of ore. This great ore deposit was well illustrated at Vienna by a model and sections, showing the position and vastness of the beds of ore, in the possession of which the Vordernberg community participates. The lignite mines of Seegraben, near Leoben, supply the puddling works and mills with 70,000 tons of fuel annually, and from the Oslawan coal mines in Moravia, the blast furnaces at Schwechat obtain coking coal. There are of charcoal blast furnaces, three at Eisenerz, and three at Hiflau, yielding about 35,000 tons annually of excellent white forge pig, and of coke furnaces, two at Schwechat, near Vienna. The latter are on the Büttgenbach system, and are 60 ft. high, 18 ft. wide at the boshes, and 7 ft. between the tuyeres, and with calcined spathic iron ore from Eisenerz, and coke made at the works from Oslawan and Fünfkirchen coal, they produce daily over 50 tons of white forge and grey Bessemer pig each, the total production of pig iron of this company being about 70,000 tons. Nearly all of this product is made into wrought iron, forge and Bessemer steel, by the works of the company at Donawitz and Ternitz.

The Reichenau Iron Company, of Edlach, exhibited at Vienna grey pig and chilled railway wheels, rollers, and projectiles made from it. Connected with this establishment are steel works, and a forge and rolling mill at

Hirschwang. The great pavilion of the iron industry of Styria, to which we have already referred, represented the other iron works, of which we name first those of the Vordernberg community, which receives the greater part of the ores from the upper part of the Ertzberg. In thirteen blast furnaces, 55,800 tons of excellent white forge pig iron were made from these ores in 1872, almost exclusively with charcoal; the smaller furnaces producing about 10 tons a day, while the larger ones came up to a production of 20 to 30 tons. The exhibits of iron ores, pig iron, slags, &c. were very instructive.

The Vordernberg-Köflach Iron Company of Graz, participates likewise in the ertzberg, and in two large furnaces it made, in 1872, 11,000 tons of forge iron, which was consumed by 11 charcoal forges and 14 puddling furnaces at Krieglach and Pichling, the latter being provided with fuel from the company's lignite mines at Köflach, near Graz. Puddled steel is also made at Pichling, and crucible cast steel in three Siemens furnaces at Krems. All the samples shown were of excellent quality. The Styrian Iron Company owns iron mines at Eisenerz and Radiner, which gives ores of equal quality with those of the ertzberg; they are smelted at Zeltweg, in a large blast furnace, with coke, and the pig iron, which is partly white, partly Bessemer pig, is consumed by the forges and a Bessemer steel works of the company. By using blast, heated to 700 degrees Cels. (1,292° Fahr.) in regenerative stoves, white and mottled pig can be employed in the converters.

We have next to notice the Judenberg Iron Works, which own a blast furnace and good iron mines at Olsa, and puddling and rolling mills at Judenberg and Hetzendorf. The former produces 4,000 tons of charcoal pig, from which excellent boiler plates and sheet iron are made at the latter, the fuel being got from the brown coal mines of Sillweg. Amongst the other iron manufacturers of Styria, who were represented at the Exhibition, we may name Baron Mayer, of Leoben, who owns blast furnaces at Vordernberg and St. Stefan, the latter being connected with an iron foundry, and the Princes of Schwarzenberg, who, at their blast furnaces of Vordernberg and Trofaiach, make white forge pig from ore of the ertzberg, and grey pig iron at Turrach, together about 18,000 tons. The first Bessemer works of Austria were erected at the latter place. During many centuries enormous heaps of refuse forge and mill slags, which contain from 40 to 45 per cent. of iron, have accumulated in all these places, and their utilisation has of late been taken in hand. We thus met at Vienna with samples of cinder pig and very good wrought iron made from it, exhibited by Josef Pösendorfer's heirs of Rottenmann, and Lohninger, of Miessling.

Leaving Styria, we found in the chemical department a very good show of iron ores, pig iron, castings, steel, and wrought iron, made by the Salzburg-Tyrol Iron Company, together with the most interesting exhibits of the Krainer Iron and Steel Works Company of Laibach, in Carniola. This company smelts at the blast furnaces of Jauerburg and Sava the spathic and brown iron ores of the Triassic tract of ore beds, mentioned above, mixed with manganese ores from Vigunsza. The fuel used is charcoal, and through the exertions of the manager of the company, Chevalier von Banz, they have succeeded in obtaining regularly spiegeleisen and ferro-manganese, with over 30 per cent. of manganese. We subjoin a few analyses, which we owe to the director-general of the company, Mr. C. Luckmann, of Laibach. Four samples of ferro-manganese contained :—

Carbon	5·33	5·31	5·28	5·27
Manganese	22·46	23·48	28·70	35·04

Four of spiegeleisen :—

Carbon	4·5	4·75	5·05	4·95
Manganese	8·34	10·50	15·40	16·14

And two samples of white radiated pig iron :—

Carbon	4·15	4·23
Manganese	8·13	9·97

Besides traces of silicium and phosphorus, the former not exceeding 0·09 in the ferro-manganese and 1·13 in the spiegeleisen, the latter not 0·18 and 0·09 in either the one and the other. There is no doubt that the production in the blast furnace of a new kind of pig iron, which contains so much man-

ganese, is quite a new feature, and a very great step in the art of making iron, the principal condition appearing to be, that the oxides of iron and manganese are as intimately mixed as possible. The reason is that metallic manganese is very difficult to reduce from the oxide by means of carbon or carbonaceous gases only, while it is done with great ease when metallic iron acts as an intermediate agent.

We finish our sketch of the Austrian iron exhibits with those of Carinthia, which were likewise arranged in a separate collection, remarkable for its clearness and good taste. The metallic industry of this province was admirably illustrated, through numerous maps, statistical tables, and a complete geological collection, by the Carinthian Museum for Natural History. At the head of the iron producers stands prominently the Hüttenberg Iron Company, of Klagenfurt, which possess 12 charcoal furnaces and one coke blast furnace at Prävali This latter was the first coke furnace erected in the Alpine provinces, and it was started in 1870. It is 55 ft. high, 15 ft. diameter at the boshes, 9 ft. at the top, and 5·5 ft. between the tuyeres, of which there are six; from calcined carbonate ores it produces daily 30 tons of white iron, the fuel used being coke from Fünfkirchen and Moravian Ostrau. The average yield of the burthen is 46·85 per cent., and the consumption of coke 1·48 ton for 1 ton of pig iron. When this furnace was started many difficulties had to be overcome, arising from the great impurity of the coke, which required a very great addition of limestone to the mixture, in order to neutralise its injurious influence. The dimensions of the charcoal furnaces of this company have gradually increased from 30 ft. in 1808 to 55 ft. in 1872, with a yearly production of 1,200 and 5,900 tons of pig iron respectively. The iron ores which are smelted by them are principally raised at the ertzberg of Hüttenberg from a bed of carbonate and brown iron ore in crystalline limestone, which sometimes attains to a thickness of 64 fathoms, and yields 50 to 52 per cent. of iron, with some manganese. From the mines of Sonntagberg and Lamberg magnetic iron ore of 45 to 58 per cent. is also raised from beds that are 3 ft. to 4 ft. thick.

The limestone used for fluxing is either dolomite from St. Paul and Eberstein, or pure limestone from Lölling. Of charcoal furnaces there are one at Hirt, making daily only 4·5 tons of white pig, one at Eberstein, producing 15 tons of the same, while two furnaces at Heft make 11 to 14 tons of grey Bessemer pig, and three at Lölling, three at Treibach, and one at Mosinz, produce either mottled or white forged pig iron. The exceptional good quality may be seen from the following analyses; *a* being Bessemer, *b* mottled, *c* white pig iron, and *d* spiegeleisen:

	a.	*b.*	*c.*	*d.*
Carbon - - -	0·62	1·25 }	3·95	{ 3·85
Graphite - - -	3·03	2·80 }		{ 0·37
Silicium - - -	1·82	0·63	0·36	0·32
Manganese - -	2·85	6·82	3·91	3·12
Phosphorus - -	0·03	0·08	—	—
Sulphur - - -	0·02	—	—	0·05

The company owns large Bessemer works at Heft, and puddling and rolling mills at Prävali and Buchscheiden, which are supplied with lignite and peat as fuel. We have further to mention Count Henkel-Donnersmark's iron works of Wolfsberg, which produce in a charcoal furnace about 1,000 tons of pig iron annually from spathic and brown iron ores of St. Leonhart and St. Gertraud, and from specular ore of Waldenstein, while there are also the iron works of Gemünd, which make 2,000 tons of pig iron, which is consumed by the puddling and rolling mills of the company. We conclude this review of Carinthian works by noticing Baron Silbernagel's exhibits. This ironmaster produces pig iron from tap and mill cinders, prepared for the reduction in the blast furnace at Ferlach, by crushing, mixing up with charcoal slack, clay,

and slacked lime, and drying. Thus 2·5 to 3 tons of very fair pig iron are made every day from the preparation, the blast furnace being 32 ft. high, with very flat boshes and a narrow crucible or hearth; it is worked with cold blast. Such cinder furnaces have existed in Carinthia since the last century; they were originally only 10 ft. to 11 ft. high, and gave every day a wolf of about 7 cwt. of "rough iron."

Next we have to make some remarks on the iron industry of Hungary, which was very well represented at the Exhibition. This country is rich in good iron ores in the northern counties, particularly in that of Zips, where at the Zeleznik Mountain, near Jolsva, in clay slate, there occurs a tract of three beds of iron ore bearing east, west, and dipping south. The first is 1 to 10 fathoms thick, with brown iron ores of 30 per cent., while the second runs parallel with the former, and is 1 to 12 fathoms thick, containing ores of 42 per cent. The third, with 1 to 15 fathoms, contains large masses of a red clay ironstone with over 50 per cent. Parallel to this ore tract is another at Rakos, on an average 10 fathoms thick, and composed of pure hard brown iron ore and hematite; the yield is over 30,000 tons of ore annually. In the Rudnik Mountain, near Rosenau, is another ore bed, known to be over 1,000 fathoms in length, and consisting of spathic and brown iron ore ½ to 10 fathoms thick. Again, at Moravitza, in the Banate, at Ruskberg, on the military frontier, and in Transylvania, large masses of iron ore have been explored. It is here that the wolf furnaces, of which we have already spoken before, are still in activity, as for instance, at Thoroczka, near Thorda, and at Plotzko, near Vajda-Hunyad. Red and brown iron ores, of 42 to 52 per cent. of iron and 3 to 4 of manganese, are smelted in these furnaces, which are 11 ft. high and 12 in. wide at the top, and 25 in. at the bottom, and worked with fan blast blown in through a single tuyere of 1·5 in. in diameter. The yield from the ore is 25 per cent. of wolf or rough iron, of which 100 lb. require 160 lb. of charcoal, while the weekly production of a furnace is 35 to 37 cwt. The wolves are broken up under a hammer, reheated and hammered out into bars.

The greatest producers of iron in Hungary are the State Railway Company, who possess an enormous mineral property in the Banate, with vast forests. The principal iron ores are found at Moravitza, and consist of magnetic, red, and brown ore of 48 to 62 per cent. of iron, some manganese, and very little sulphur and phosphorus. These ores are mixed with blackband ore from Szekul, which contains 45 per cent. of iron, and with manganese ores from Tirnova. All the lump ores are well calcined and broken up in stone breakers before they go to the furnaces, of which three are at Reschitza, and one at Bogschan. The furnaces are of large dimensions, and produce either dark grey Bessemer pig, or white and mottled forge pig, with charcoal and hot blast. The company owns also two charcoal furnaces at Dognaska, which smelt magnetic, red, and brown ores from that neighbourhood, and two coke blast furnaces at Anina, where from clay ironstone, magnetic and brown ore, dark grey iron is produced with coke made in 20 Gobiet coke ovens from washed coal, derived from the collieries at Doman and Szekul. The annual production in 1872 was 18,000 tons of charcoal pig, and 2,000 tons of coke pig iron, this produce being consumed by the forges and mills, and the Bessemer steel works of the company, these being the only ones in Hungary. The company own steam engines of 2,600 horse power, employ 4,500 men, and produce one quarter of the iron made in the kingdom.

We notice next the Royal Hungarian Iron Works of Rhonitz, to which belong also the works at Brezova, Teissholz, Libethen, Poinik, Mostenitz, Waiskowa, Jassena, Polhora, Zeleznik, Dobschau, and Göllnitz, which all use charcoal as fuel, and smelt the iron ores of the northern ore tracts mentioned above. They produced, in 1871, nearly 10,000 tons of pig iron, which were consumed in the puddling works and forges belonging to the Government. At Rhonitz from 25 to 50 per cent. of cinders are smelted with the mixture, and at one of the furnaces there is an interesting gas collector in operation, constructed by Julius Navay, after a combination of the Langen and Kerpely systems, which allows the fuel to be charged in the middle, while the ore burthen rolls towards the circumference. The products of the works and the ores were well exhibited at Vienna.

The iron works of the Rima-Murang Iron Company smelt the excellent ores of Zeleznik and Rakos in five charcoal furnaces. The brown iron ore of the former contains 50 to 60 per cent. of iron, and 2 to 5 per cent. of manganese, the spathic ore 42·5 per cent., and that from Rakos 39 to 40 per cent., while hematite from these mines holds 57, and specular iron ore, 43 per cent. of iron and manganese. The iron is partly used for very good castings, partly made into wrought iron in puddling furnaces, which latter are fired with tertiary coals from Ozd and Nadasd. The Diosgyör Iron Works, near Miskolz, belong also to the Hungarian Government, and are not many years old. They comprise charcoal blast furnaces and a forge and rail mill; the former smelt the iron ores of the neighbourhood, where brown iron ore is found in beds in chrystalline slates of the Tatra mountains. The puddling furnaces are supplied with Tertiary fuel.

Amongst the smaller iron works, which exhibited their ores and pig iron, we need only name here the Austro-Hungarian blast furnace company, the Krompach-Hernad Works, which make 1,700 tons of foundry pig, the Bujakowa Works of Daniel Pryhadni's heirs, the Betler Works of Count Nadasdy, which from two blast furnaces make about 3,000 tons of grey Bessemer pig, with 4 to 5 per cent. of manganese, and the Also-Sajo Works of Count Em. Andrassy, which also with two furnaces make 6 to 7 tons per day of white pig iron and spiegeleisen, from carbonate and brown ores. Count Waldstein-Wartemberg, of Boros-Sebes, in Transylvania, showed very good spiegeleisen, with 7·5 per cent. of manganese, and the Plotzko Iron Works iron, which was made in wolf furnaces, and is mentioned above. The iron ores of these and of the Royal Hungarian Works at Sebesheley, Govasdia, and Kudricz, come from the celebrated Gyalar iron mountains, near Vajda-Hunyad, which, embedded in mica-schist, contains a bed of rich and manganiferous ores, alternating with crystalline limestone, and often 50 fathoms thick; it is computed to contain at least 112 millions of tons. The ore is free from sulphur and phosphorus, and contains 51 to 53 per cent. of iron, and 3 to 5 of manganese.

The Kronstadt Mining and Smelting Company own iron works at Ruskberg, Ferdinandsberg, and Stefansberg, and very important iron mines at Telek, which continue to Gyalar, and produce a similar ore which is smelted with charcoal at Ruskberg. A trial to use coke made from Tertiary coal of the Zsill Valley, had no economical success, although it showed its practicability. Prince August, of Coburg, is proprietor of the iron works at Gran and Kapsdorf, the former comprising the furnaces and forges of Rothenstein, Pohorella, Svabolka, and Ferdinandshütte, which produce 4,000 tons of pig iron, besides castings, bar and sheet iron, and the latter a group of works near Kapsdorf, to which belong the blast furnaces of Sztraczenna, which made from 4,500 to 5,000 tons of charcoal pig iron. In Croatia and Slavonia only a couple of small blast furnaces exist at Rude, near Samobor, at Petrovagora and Tergrove. At Rude, considerable beds of spathic iron ore, 15 fathoms thick, with 38 per cent., and a bed of red hematite with 61 per cent., have been explored, while the furnace of Petrovagora smelts mostly bean iron ore, and that of Tergrove spathic and brown iron ore; these are being found in beds belonging to the lower coal or culm formation. A new blast furnace, with the same kind of ores, is to be started at Bestinac. The total production of all these works hardly exceeds 4,000 tons, but owing to the vastness of the forests, and the good quality of the ores, it could be considerably increased.

Russia's production of pig iron was in 1871 about 360,000 tons of which 303,000 tons was white forge pig, the fuel being almost exclusively charcoal. Among the exhibits from this country at Vienna, we noticed those made by Paul Demidoff, of Nischnei Tagilsk, in the Ural Mountains, where from excellent magnetic iron ore with 65 to 68 per cent. of iron, a very strong and grey pig iron is made with charcoal; it is consumed in the manufacture of rails, bars, and sheets. The annual production is about 20,000 tons of pig iron. The iron works of Kataw-Iwanowsk, belonging to Prince Bielosersky, make about 7,000 tons of grey and white forge iron from brown iron ore of 50 per cent., and the furnaces of the district of Goroblagodat produce

annually from ores of the Blagodat iron mountain, 17,000 tons of very good charcoal pig.

We must not forget to mention the iron works at Kischtim, the property of Rastorgujef's heirs, with a production of over 14,000 tons, and the works of Countess Stenbock-Fermor, which make 18,000 tons of pig iron from excellent magnetic and brown iron ore, which is converted into wrought iron, either in gas puddling furnaces or charcoal forges. Pig iron of the same quality is also produced at the Government furnaces of Zlataoust for the supply of the cast steel works and the small arms factory of that place. In Southern Russia where good coking coal is found, the iron industry has still a great future, though it is not yet developed, and iron exhibits were shown from there only by the iron works of Lissitschansk and Longansk, and good brown iron ore, which now yields 35 per cent. of iron from Orokhowo. From Finland we found samples of bog iron ore and grey pig iron, shown by Prince Poutiloff's iron works, which contain four charcoal blast furnaces and a large forge and rail mill, with an annual production of 36,000 tons. From Poland samples of pig iron were exhibited made at Count Soltyk's works of Chlewiska, and by Warschawsky, Horwitz, and Kallet, at Raivolo. As Poland is in possession of good coking coal and of very good iron ores of the trias limestone, a considerable development of the iron industry may here be looked for in the course of time, when charcoal will have become as expensive a fuel as it is now in most of the other European countries.

The iron exhibits of Turkey, China, and Japan were quite insignificant and hardly deserve to be mentioned. We here therefore conclude our sketch of the iron ores and pig iron products represented at Vienna, and we shall be happy if we have succeeded in giving to our readers a general picture of the manufacture of pig iron in the principal countries of the globe.

General Castings.

After the manufacture of pig iron had made sensible progress, the next step towards utilising the products of blast furnaces was the conversion of the molten pig iron directly from the blast furnace into castings of different forms and characters, or the previous re-melting of the blast furnace pigs in reverberatory, or cupola furnaces, before running the metal into the moulds. As the importance of the iron industry in general increased, and the dimensions and volumes of the manufactured articles became greater, castings, as a fundamental part of all iron constructions, necessarily gained in importance, and at the same time in volume and complexity.

It is to be deplored that the general interest and utility of the subject has not, until very lately, induced engineers and proprietors connected with this important branch of iron industry to publish their experiences in the art of moulding and casting, and so to aid in generalising the data and facts connected with the successful management of foundries. It seems that this branch of iron metallurgy has, up to our time, been treated like so many other arts of the middle ages, when the whole system of carrying out work was opposed to the generalization of knowledge. Indeed it must appear as a very curious fact, that in hardly any of the published treatises on iron and metallurgy is the art of casting fully and practically dealt with. Notwithstanding the mystic veil which, for a long time concealed the art of casting from the eyes of professional metallurgists, mouldings and castings belong to the oldest metallurgical processes known, and long before iron was used for war purposes, or more innocent undertakings, castings were made of bronze, and the nature of the latter, as a substitute for iron, seems to have induced the metallurgists of ancient times to have recourse to this simple mode of giving to the metal the desired shape and form.

We found an interesting testimony of the antiquity of this art in the Vienna Exhibition, where, amongst many objects of bronze found in the lake of Brienne, several moulds for bronze knives and other articles of the same material are exhibited, these belonging to a period of far more than 2,000 years ago.

One of these moulds, all of which consist of a grey sandstone of great porosity, has been found completely preserved, and is represented by Figs. 2, 3, Plate XXXIII. Both parts of the moulding box, if we may call it so, have

corresponding holes, *d d*, of about ¼ in. in diameter, nicely drilled out, into which probably pieces of wood were introduced to keep both half parts in their proper relative positions during the operation of casting. The inlet at *a*, as well as the mould itself, is still blackened from the influence of the molten bronze on the sandstone. Bronze knives of the same form and dimension as the mould shown by the sketch, are exhibited in the same collection, and seem to have been manufactured with the apparatus described.

When the demand for iron castings increased, and their form and dimensions became more and more complex, great difficulty was encountered in finding skilled workmen and reliable foundry engineers, with sufficient knowledge and experience in moulding and casting, to carry on the business. Such was the necessary result of the exclusive character evinced by iron-founders in general, and at the same time the reason why only a relatively small number of foundries were in a position to carry out heavy and complicated castings. Now as science proceeds, the exclusiveness of this branch of iron industry is rapidly disappearing, and the progress shown in this particular manufacture proves the unrelenting diffusion of engineering knowledge.

Certainly, for some purposes, where an extra quality of iron is wanted, a monopoly will ever be held by a few foundries having at their disposition ores and pigs specially adapted for the purpose; but the general use of castings does not involve the necessity for the best qualities of iron, and it is precisely in this department where we see great progress made of late years.

We may divide the castings as exhibited in Vienna into four classes, not taking into consideration the "art castings" proper, as the latter will form a subject for future consideration. At present we shall regard the question chiefly from the metallurgical point of view. We shall treat here, therefore, of:—

1. Castings with respect to dimensions, form, and general quality of products.
2. Castings where the production of large quantities in a specified time is the point aimed at.
3. Castings where strength of the material used is the principal object.
4. Malleable castings.

Art castings we shall treat subsequently in an independent division.

If we take into consideration the fact that the increased dimensions of the greater number of metallic constructions has necessitated an appropriate increase of all cast-iron details, and that not only the weight and dimensions, but also that accuracy and nicety of the produced castings has been felt to be necessary, we are bound to acknowledge that the art of casting large and complicated piecework has made undeniable progress.

France always had the reputation of making the finest castings, owing to the exquisite moulding sand they have at their disposal. Next to France the most accurate and best castings are made in England, which was proved by the excellency of the cast-iron details furnished in all machines and tools. Creusot exhibited a steam cylinder for a marine engine, taken untouched from the mould, an excellent example of the performance of the foundry department. This cylinder had a diameter of 37¾ ins., a stroke of 39·37 ins., and weighed 7 tons. It was the finest casting of this kind to be found in the Exhibition.

The Société John Cockerill exhibited a large blowing engine of the Seraing type, which we have described elsewhere,* and the air cylinder of which is a good example of what these works can produce. This cylinder has a diameter of 118·11 ins. and a stroke of 96·06 ins. Blansko, in Moravia, exhibited good examples of very complex castings, such as the valves of the water mains in Vienna. These mains have a diameter of 3 ft. and are tested to 15 atmospheres; the working pressure is 5 to 7 atmospheres. The valves had to be strengthened accordingly, and were changed several times before they stood the severe test. They are furnished with a number of ribs outside and inside, vertical as well as horizontal, thus making the valve boxes a very complex and difficult casting. We are glad to say that the valves and valve boxes have stood the test without leakage and without the least sign of injury.

* See Section VI.—Stationary Engines.

Wheel castings have been made a very interesting speciality, and America took the lead in this industrial branch. The iron used there is specially adapted to such castings, combining great strength with great hardness in the chilled portions of the wheel. The Royer Wheel Company, Cincinnati, and the Ramapo Wheel Foundry Company, Ramapo, New York, exhibited very good specimens of chilled cast-iron wheels. Besides the American exhibitors of cast-iron wheels, the latter have been exhibited by the Arboga Works, in Sweden, and by Count Andrassy, at the Dornö Works, in Upper Hungary, and by Ganz and Co., in Pesth. These two last exhibitors have manufactured large quantities of such wheels, and in fact have furnished all the cast-iron railway wheels running on the Austrian lines. These wheels consist of two convex discs joined together by the centre and the tyre of the wheel, the whole being cast in one. Great care must be taken in the selection and mixture of iron to obtain the requisite chill on the tyre surface without straining the other parts of the wheel. These wheels have an average endurance of five years, after which time they must be recast. The cost of maintenance, including the cost for recasting, is about 4*s.* 7*d.* per year, as an average of ten years. We give some other particulars of these wheels in the section dealing with railway rolling stock.*

Besides these wheels, chilled cast-iron crossings have come into extensive use. De Maré, of Ankarsrum, Sweden, exhibited a crossing which has been in constant use at Arwica, a very busy station of the Swedish States Railway, without showing any visible sign of deterioration. In the departments of France, Germany, and Austria, we encountered several more exhibits of such chilled cast-iron crossings. A speciality of yet more confined manufacture is the production of chilled cast-iron rolls. It is to be deplored that England was not represented in this branch, which is a well-known speciality of English ironfounders. The Austrian States Railway and some iron manufacturers of Styria and Carinthia displayed numbers of these articles, but as these products only can be judged by the results obtained in working, it is difficult to express a preference for the one or the other of these exhibits by mere inspection of the metal, the chill, and surface. The only firm, which, according to long experience, has excelled in this sort of manufacture on the Continent, and which exhibits beautiful samples of chilled rolls for plates and different sorts of round and square bar iron, is the Royal Iron Manufactory at Königsbrunn, Wurtemburg.

Last, but not least of the specialities in artificial castings we have to mention, is the manufacture of anvil blocks, which more than anything else show the constant increase in the dimensions and weights of manufactured articles.

Russia exhibited a model of one of the largest anvil blocks ever cast in one piece. This anvil block, weighing 622 tons, is destined for the large 50-ton double-acting steam hammer of the Imperial Steel Works at Perm. To those who never had to do with such work the casting of an iron block of similar dimensions seems to be an easy task; yet nothing can be more exciting than the handling of large masses of molten iron, if we take into consideration the temperature of the liquid, the weight of the mass itself, and of the apparatus necessary for moving it, the rapidity with which all operations must be carried out to avoid the setting of the material, and lastly the loss in case of failure, it being nearly impossible to make any use of such a big block of metal. Under these circumstances the following detailed account of the mode of carrying out the work will be of interest.

The gun factory at Perm, a town situated on the banks of the river Kama, in the north-eastern part of Russia, belongs to the Russian Government, and was erected by Mr. Woronzow, imperial mining engineer, for the purpose of manufacturing cast-steel guns of large calibre. Up to the present the steel blocks used for these guns have been forged under a 15-ton hammer, but the ever-increasing requirements proved the insufficiency of this tool, and Mr. Woronzow decided to erect a large double-acting 50-ton hammer calculated when using top steam to be equal in effect to a single-acting 100-ton hammer. The drawings of this hammer, as well as a model of the anvil-block, were

* See Section VIII.—Railway Rolling Stock.

exhibited at the Vienna Exhibition. The anvil-block was to be a solid mass of iron 500 tons in weight.

The works began in the summer of 1869, when the foundation for the anvil-block was commenced. First it was necessary to ascertain the geological formation of the ground upon which the hammer and the anvil-block were to be erected. Borings were consequently made, and these showed the following stratification of the ground: A, red and blue clay, 23 ft. thick; B, coarse sand, and boulders, 6 ft. thick; C, very wet and fine-grained sand, 7 ft. thick; D, fine and strong sandstone, but very much cleft in all directions; E, dense and compact grey slate (called Wapp) with imbedded portions of gypsum. This slate was bored to a thickness of 63 ft. without being traversed. As this slate showed a resistance of 680 lb. per square inch it was considered a good basis for the foundation. The excavation was performed in a way often adopted in sinking bridge piers, with a water tight caisson and compressed air, on account of the two strata B and C, which contained a quantity of water. The air was compressed to 16 lb. per square inch in the caisson. After having reached the slate and entered it to a depth of 7 ft., the surface was levelled and covered with two cross layers of 12-in. larch beams *m* (see Fig. 1 on Plate XXXIV.), which were strongly painted with tar and covered with a layer of felt. Upon this came three courses of strong sandstone masonry *n n* laid in cement. Each of the stones used in this construction had a weight of from 16 to 19 tons. This change of wood and masonry was repeated twice more, and the whole ultimately covered by a double course of larch beams, upon which the anvil-block was to be placed.

This foundation, shown by Figs. 1 and 2 on Plate XXXIV., having been completed by the month of October, 1871, the pile driving for the foundations of the main hammer buildings began and was continued during the whole winter. The central part of these buildings for containing the hammer is a tower-like structure, and consists of an iron roof supported by four wrought-iron pillars of $\frac{1}{2}$ in. boiler-plates. The surrounding buildings for the boilers, welding, and reheating furnaces are of a similar construction.

In October, 1872, the central tower was completed, and the preparations for casting the anvil-block were begun. The latter has the form of a prism with a base 16½ ft. square and 5 ft. high, joining a pyramid 9 ft. high, and with a top 9 ft. 8 in. square. The cubical contents of the whole block is therefore 2,700 cubic feet. To compress the iron on the top of the anvil-block, it was decided to cast the block upside down; it was necessary therefore to furnish it with two trunnions *g g*, upon which it could be turned to its proper position after having cooled. These trunnions *g*, at the same time, served as inlets for the molten iron during the casting.

The block was cast on the top of its definitive foundation, and after the casting pit had been well dried and warmed, the moulding itself began. First of all a strong iron framework *i i* was erected in the pit around the sides of the block, this consisting of vertical cast-iron beams covered with 2 in. cast-iron plates, the whole firmly held together by strong tie-rods. The hollow space in this structure was filled with moulding sand. This completed, four layers of common bricks *o* were placed on the bottom of the mould, namely, on the top of the foundation, all these being laid in loam and well dried. In the second layer of these bricks several flues were provided for the escape of steam and gases. Upon the common bricks four courses of firebricks *p p* were placed in such a manner that in the first course the bricks were laid flat, and in the three others they formed an inverted arch. A mixture of fireclay and quartz served as mortar and filling material. Upon this followed three layers of firebricks set on end, after which the sides of the mould were built up with large firebricks (two and a half times as long as the common bricks), and the space between this brick wall and the iron framing was firmly rammed with moulder's sand. Cast-iron pipes were fixed in this sand for the escape of the gases. The trunnions and the channels for the liquid iron, were moulded in the same manner.

Simultaneously with the preparation of the mould, the following works were carried out:

a. The Erection of the Cupolas for Melting the Pig Iron.—14 Mackenzie cupolas A′ A′ A′ were erected around the mould. These cupolas had given such highly satisfactory results on a previous occasion at Perm, that they were considered the best adapted for the present work. The cupolas were constructed upon a brick foundation with an elliptical cast-iron bedplate 2½ in. thick. Each plate had a projecting rim which kept the cupola proper in place. The latter was made of boiler plates lined with fire-bricks 4½ in. thick. The space between this brick lining and boiler plate shell was rammed with quartz sand, which also served for the bottom lining of the cupola.

b. The Provisions made for Supplying the Necessary Blast to the Cupolas.—According to the experiments made at Perm in working Mackenzie cupolas with anthracite, it was found that for the proper melting process not less than 4,000 cubic feet of air per minute ought to be supplied to each of the cupolas. To provide for so large a quantity of blast for the 14 cupolas, three blowing engines were adapted to this purpose, namely:

1. A horizontal blowing engine, with four blowing cylinders, worked by a 120 horse-power two-cylinder engine. The diameter of blowing cylinders was 6½ ft., and stroke 7 ft., the engine making from 22 to 24 revolutions per minute.

2. A vertical blowing engine of 60 horse-power, having two blowing cylinders of 6 ft. diameter, and 7 ft. stroke, making 21 revolutions per minute.

3. A newly constructed blowing engine with two cylinders, the pistons of these cylinders, as well as of the steam cylinders, being fixed to common piston rods. The blowing cylinders of this engine have a diameter of 8 ft., a stroke of 7½ ft., and make from 14 to 17 double strokes per minute. The blast from the last named engine entered a cylindrical regulator of boiler plates, 7 ft. in diameter, and 28 ft long, and left it through a 23 in. pipe, B′ C′. The blast of the two first named blowing engines was carried through pipes of the same diameter. These three pipes united to one which carried the blast to the different cupolas at a distance of 640 yards. 141,120 lb. of anthracite, 114,240 lb. of coke, in all, 255,360 lb. of fuel, and 1,786,400 lb. of pig iron, obtained mainly from the well-known Blagodat ores, were weighed and prepared for the working of the cupolas. On the 26th of January 1873, at 3.15 a.m., the cupolas were lighted; at 3.45 a.m. the blast was turned on with one engine working; 10 minutes later the second, and after the lapse of another 10 minutes, the third blowing engine was set to work, when the blast pressure was increased to its full force; at 4.5 a.m. the iron began to melt, and the tap holes, which before that time had been kept open, were plugged with clay. Three minutes later the first tapping of iron took place, and the metal entered the mould. In this working order the cupolas were kept during two hours; at 6 a.m. they were cleaned for the first time, which operation was completed at 7.40 a.m., after which some repairs became necessary, which, however, were successfully completed in time to begin with the melting at 10.20 a.m.; at 3 p.m. the cupolas were stopped the second time for the sake of cleaning, when the iron in the mould had reached a height of 10 ft. from the bottom, which corresponded to a quantity of 880,000 lb. of iron; at 7.25 p.m. the cupolas again were filled with materials, and at 10.35 p.m. the blast was turned on; at 11.15 p.m. the iron was tapped, and continued running into the mould till 4.3 a.m., when another cleansing and repairing of the cupolas became necessary. It was found at that time that only 24,000 lb. of iron were wanting to fill up the whole mould, and it was decided therefore to work only 10 cupolas for this last portion of the melting. These cupolas were set to work the 27th of January, at 5.26 a.m.—the first tap took place at 7 a.m., and at 7.21 a.m. the whole operation was over.

The following shows the results of the melting operation:—

First Melting.

Filling 1st consisted of	1,520 lb.	anthracite and	7,600 lb.	iron.
„ 2nd, 3rd, and 4th	800	„	„	7,200	„
„ 5th and 6th ...	480	„	„	3,600	„

After this all the 14 cupolas together were worked in the following manner:

54,880 lb. anthracite 13,440 „ coke	}	509,600 lb. iron.

Second Melting.

To the fourth filling coke was added, and the whole materials used were:

43,720 lb. anthracite 26,880 „ coke	}	516,800 iron.

Third Melting.

Total	20,880 lb. anthracite 47,040 „ coke	}	459,200 „

Fourth Melting.

Total	15,200 lb. anthracite 19,200 „ coke	}	220,000 „
Total result	136,480 lb. anthracite 106,570 „ coke	}	1,724,000 „

95,720 lb. of iron were taken out of the cupolas after the completion of the works.

After the mould had been completely filled the iron surface was covered with coal dust, and was allowed to cool. On the 29th of January a thin crust formed on the iron surface, which could easily be pierced. It was anticipated that it would be necessary to fill up the mould the next day, but after having pierced the hardened crust on the top of the liquid iron, the latter was found to be under a state of compression by the contraction of the cooling surface, so that instead of forming the well-known phenomenon of hollows the iron came up oozing through the pierced hole. On the 31st of January the above mentioned crust had become so hard, that it could not be broken by a blow of 720 lb. weight. The whole mass was then allowed to remain undisturbed for three days. On the 3rd of February the moulding sand around the iron moulding frame was removed, the temperature of the cast-iron beams of the latter was 158° Fahr.; on the surface of the 28 in. sand covering on the top of iron block it was 194° Fahr., with a temperature of 14° Fahr. in the outer atmosphere. On the 24th of February an endeavour was made to measure the temperature of the casting proper, and for this purpose several holes were drilled into the sides of the anvil block, and in these different metals were inserted to ascertain the temperature of the iron. It was found that antimony would melt, and even ignite, whereas brass did not melt. On the 26th of March, zinc would remain unaltered, while lead melted rapidly. According to these trials it was found that the temperature of the casting diminished at the rate of 72° Fahr. per day at the outset, then at the rate of 54°, and towards the end of the cooling at the rate of 32° Fahr. per day.

This casting reflects every credit upon the skill, energy, and circumspection of the engineer, Mr. Woronzow, aided by a well-trained and clever staff. The economical results were equally satisfactory, as the whole work was completed at an outlay of 63,000 rubles (about 10,000*l.*) or at the rate of 1 ruble 75 kopeks per pud, or about 15*l.* 16*s.* 11*d.* per ton. The difficult operation of turning the anvil block into the proper position was also successfully carried out in the month of October 1873. The block was turned round on its journals by two steam engines, and this was done within two hours and a half.

The writer of the present lines having himself had occasion to superintend some such castings, of 50 and 100 tons respectively, is well able to judge of the difficulties in dealing with about 700 tons of molten iron. The plan adopted in one of the above named cases, and which we think is the best manner by which most of the difficulties may be overcome, was the following: Two large cupolas, with sufficient yield to finish the charges necessary for the casting within 12 hours, were set close to the pit and connected with a

heating chamber expressly built for the purpose. This chamber was constructed of firebricks, and was about 8 ft. by 6 ft., and 5 ft. high. It was covered by a firebrick arched roof, and the whole structure was held together with strong iron plates and tie rods. The chamber was heated with coke the whole day previous to that on which the casting was to be made, and a red heat of the firebricks obtained, sufficient to keep the metal run into the chamber in a perfect liquid state for at least 12 hours. When the whole of the iron necessary was molten in the cupolas, and successively tapped into the heating chamber, the latter was tapped, and the iron allowed to run into the mould in a large and continuous stream. With this precaution a casting of perfect toughness and soundness was obtained.

Great care must be taken in preparing the mould for such large castings, and it has been found the best plan to divide the whole mould into several separate parts, which can be thoroughly dried in a drying stove, and are only replaced in the mould pit the day before casting. In this manner, not only the perfect dryness of the mould, but the principal condition for the production of a sound casting can be secured.

Castings of the class in which rapidity of production is an essential requirement are especially represented by gas and water pipes, these forming the subject of a well-defined branch of iron founding. Most of the pipes shown at the Exhibition were of French origin, and with the exception of the Belgian department, other pipes were exhibited only in the Austrian court. The large waterworks of Vienna, as well as those of other towns of the Austrian empire, gave a fresh impulse to this sort of industry, and we may especially mention the products of the Imperial States Railway Company, of the Prager Eisenindustrie-gesellschaft, and of the Blansko, Mariazell, and other foundries.

The French and Belgian pipes are moulded by machinery, and most of them are 9 ft. long, some even more than 12 ft., whereas nearly all the larger pipes in Austria are cast in lengths of not more than 6 ft. The Société Metallique de Vienne Hauts Fournaux et Fonderies de Montmorillion, exhibited water pipes of 9 ft. 10 ins. in length, and of different diameters, up to 39·37 ins. The exterior of these pipes was in no way very creditable, showing many signs of want of liquidity in the metal during casting. The pipes of the Société Anonyme des Hauts Fournaux de Marquise were 13 ft. 1½ in. long, and painted over, like those exhibited by Haldy, Roechling, and Co., so that the exterior of the castings could not be judged.

Many ingenious contrivances have been invented and set to work for facilitating and accelerating the process of moulding pipes, and French, English, and Belgian ironfounders have expended large sums of money in the erection of moulding machines. The late general manager of the Neuberg Mariazell Iron and Steel Company, in Styria, Mr. Joseph Stummer-Traunfels, has patented a very ingenious and simple arrangement for moulding pipes of any dimensions with great accuracy and rapidity. The details were invented conjointly with Mr. Laurin, the foundry foreman of Mariazell. His arrangement, which is represented in Figs. 8, 9, 10, Plate XXXIII., is specially adapted for foundries where great quantities of pipes have to be manufactured, and where large sums of money cannot be expended for the installation of moulding machinery. The present apparatus is very cheap, and is to be preferred to complicated moulding machines as used in Belgium and other parts of the Continent, in all foundries where pipe casting is not the sole object of the establishment. These arrangements have worked for more than three years at Mariazell with the best results, and the large water mains (3 ft. in diameter) of the Vienna Water Works were all moulded with them.

Fig. 8, Plate XXXIII., shows a vertical section of moulding box, core spindle, casting box, &c., ready for casting. The moulding-box is composed of four parts *a*, *a*, *a*, *c*, which are connected horizontally and vertically by flanges and screws *b*, *b*. This box is mounted upon a plate *c*, *c*, and fixed in the proper position by the pins *d*, *d*. The spindle is a movable one, and consists of a wrought-iron central rod *e*, *e*, held in its position by the cast-iron piece *f*, *f*, which is securely fitted in the bottom plate *c*, *c*, so that the rod *e*, *e*, is

always kept in the same vertical position. The rod is movable in a vertical direction through the bearings of the piece *f, f.*

Cast-iron T-shaped bars *g, g,* are attached to this spindle by means of the movable links *h, h,* so that by lifting the rod *e, e,* the bars *g, g,* will contract parallel to the central rod. The length of the movable links is adjusted so as to press the bars *g, g,* just against the rim *i, i,* of the bottom plate *c,* when the central rod is in its lowest position, as shown in the drawing. The form of section of the bars *g, g,* is to be seen in Fig. 10. They are T-shaped, with recesses along both sides to take up perforated wrought-iron plates *k, k, k, k,* bent according to the diameter of the core, and completing the periphery of the latter. These plates are kept in position partly by the rim *i, i,* of the bottom plate, partly by iron rings *l, l,* fastened with screws (Fig. 10). A movable lever *m,* is also attached to the piece *f, f,* for keeping the spindle rod *e, e,* in place during the moulding and casting operation, and by these means to avoid the collapsing of the core. The lever keeps down the rod *e* by means of the screw *n,* shown in Fig. 8.

The mode of operating is as follows:—When the core spindle is fixed in the manner described, a cast-iron plate is put on its top in the recess at *p, p,* to prevent sand or other material from falling inside the core. Then the lower half of the pipe model *a, a,* is put in place, and the lower half of the moulding-box, which is of a corresponding height, is fixed to the bottom plate by means of the pins *d, d.* This having been accomplished, the moulding sand is rammed both inside and outside the pattern to the height of the lower half of the moulding-box. When this is done the second half of the pattern (consisting in itself of two parts), and of the moulding-box, is put in place, and the ramming of the sand completed. Then the moulding box is divided into two halves by means of the vertical flanges, the screws of which are taken out and the two half cylindrical parts of the moulding-box removed, so that the pattern itself can be taken out and the surface of the sand smoothed, &c. It will be seen at once that this sort of moulding has the great advantage of allowing any rings or outside protruding parts to be moulded without the least difficulty (Fig. 8). Besides these reinforcements *r, r,* the Vienna water pipes have a small recess at *s* to keep the lead in place when the pipes are jointed. Owing to the very minute dimensions of this annular space it could not be well formed in sand on account of its want of resistance against the liquid metal running down the sides of the core. To obviate this a ring of several segments of burnt clay is inserted in the core after the moulding, as shown.

When all this has been completed, and the moulds well dried, all is put together, and the casting-box *t, t,* is fixed on the top of the mould, and the liquid metal poured into it at *δ,* it is distributed through the channels *β, β, β,* into the ring *e, e,* and from this runs down to the mould through the openings at *δ,* which are placed so as to prevent the metal from falling down directly in the mould, but to make it run over the sides of the core. Between the casting holes *δ, δ, δ,* separate holes are provided for the escape of gas.

When the mould is filled and the iron has set, the casting box is removed, the inlets *δ, δ,* are broken off with a hammer, and the lever *m* turned aside after having loosened the screw *n*; then the spindle rod *e* is lifted a few inches with a crane, and the core spindle collapses at once, leaving room for the iron to contract. After a few minutes' rest the moulding-box is removed bodily, taking with it all the sand and the cast pipe, the whole adhering firmly enough to allow its being raised out of the pit and put aside for cooling. By this means the pit and the core spindle always remain perfectly clean and are ready for immediate use.

A very nice contrivance for moulding the outside of the pipes separately from the core is shown in Figs. 11, 12, and 13, Plate XXXIII. This apparatus forms a part of the patent for the moulding machinery above described, and consists of a table *b, b,* which is moveable on the bedplate *g, g,* by means of the screw and nut *f, f.* The pattern of the pipe is firmly fastened to the table *b, b,* so that it can be moved to and fro with the latter. The two standards *d, d,* like the movable scenes in a theatre, are firmly screwed to the bedplate *g, g,* and, with their vertical planes *m, m,* represent a door for the model to pass through, nearly touching it in its profile when the plane of the two standard

planes *m m* cuts the axis of the model. In this position it presents correctly one-half of its periphery on the outer side of the two planes *m m*. The half moulding-box *w w* is then placed on the bedplate, and fixed upon it in such a position as to touch the planes *m m* with its flanges. This done, the sand is rammed into the space between the pattern and the moulding box in the ordinary way. After the moulding operation the model is moved backwards by means of the screw and the mould left perfectly clean. The moulding box is then removed and dried, when it will be ready for use. This arrangement allows of a great number of castings to be made with one core spindle, as the moulding-boxes can be kept on store.

In the Machinery Hall at the Vienna Exhibition, Mr. George L. Scott, of the Crown Iron Works, West Gorton, Manchester, exhibited in use his well-known patent wheel-moulding machine, largely used in England and on the Continent. A similar machine, copied from one of Mr. Scott's earliest patents, was also exhibited by Mr. Zimmermann, of Chemnitz, the well-known tool maker, notorious for the ability he shows in copying English machines and tools, and selling without acknowledgment.

The accuracy and perfection of toothed wheels are of great practical importance in all cases of gearing, and it is requisite for the transmission of power by them that the teeth of the wheels should be uniform, and that their action should correspond with the uniform frictional contact of two plain circles rolling upon one another. To maintain this uniform and continuous action with toothed wheels, it is requisite that the form, size, and spacing of every tooth throughout the circumference of the wheels should be exact duplicates of one another, and perfectly uniform throughout, and also that the teeth should be placed in a perfect circle round the wheels.

It was with a view of obtaining this requisite perfection of form, and enabling strictly accurate wheel castings to be produced by machine moulding, that Mr. George L. Scott designed his admirable arrangement of wheel-moulding machine, of which we give illustrations on Plate XXXIV. Mr. Scott has had a long and varied experience in foundry matters, and the moulding machinery he has devised not only satisfies the practical requirements of the case very perfectly, but is, comparatively, of low cost, and possesses the great convenience of being capable of being readily and quickly applied at any part of a foundry.

The engravings which we give on Plate XXXIV. descriptive of the machine and the process of moulding wheels by it, are—Fig. 3, side elevation of machine; Fig. 4, plan of machine; Fig. 5, section of foundry floor and process of moulding a bevel wheel; Fig. 6, section of foundry floor and process of moulding a spur wheel; Fig. 7, plan of Fig. 6; Fig. 8, bevel wheel segment attached to machine; and Fig. 9, pedestal of machine. By referring to Figs. 5 and 9 it will be seen that a pedestal A, supports a spindle B, which has a collar bearing on the pedestal, and is so fitted that it cannot turn in it. In Fig. 3 it will be seen that a second spindle C is bored to fit on B, and is also turned to pass through the rest of the machine, two set screws placed in the spindle C firmly securing it to the spindle B. Loose collars 2 in., 4 in., and 6 in. in breadth are bored to fit spindle B, and are used to elevate the machine according to the breadth of wheel required to be made. As previously stated, the spindle C passes through the head or centre D, Figs. 3 and 4, in which slide the parallel arms E and E*, Fig. 4, bolted together by a loose piece at the end and at the front by another piece F, which also acts as a bed for the triangular sliding ram G. Two T slots, one in each arm, are provided for the purpose of securing them by T bolts to the head D, when at any required radius. This form of construction allows the head D, with the arms E and E* (forming a mechanical trammel) to revolve on the central axis C.

On the spindle C, Fig. 4, is keyed the worm wheel H, which is connected to this trammel by the dividing arrangement consisting of the worm *a*, Fig. 4, on the shaft of which is keyed the change wheel *b*, gearing into the intermediate wheel *b'*, the latter gearing in *b''*, Fig. 3. The change wheel *b''* is keyed on the handle shaft *d*, carried by two brackets on the arm E*, Fig. 4. The handle shaft *d* is provided with a loose collar for a bearing, and also that the shaft may be withdrawn to alter the change wheels when

required. The swing frame *c* carries one or two intermediate wheels as necessary. On the shaft *d*, Fig. 4. is fastened a spring handle *e*, which fits a slot recessed in the disc *f*, divided to guide the workman in the number of turns to be made by the shaft.

On the arm E, Fig. 4, are brackets for carrying the screw L, which (through the nut K, bolted to the head D, and by means of the hand-wheel, *g*,) moves the arms in or out to suit various diameters. On the slide bed F, Figs. 3 and 4, fits the sliding ram G, which is also supported by the slide cover I, in which is a hand screw R acting as a retainer, and holding the ram at any required position. The bottom of the ram is bored to receive the angle plate or bracket M, secured also by steady pins, and to which is attached the segmental pattern V, consisting of two teeth of the wheel required, allowing one space to mould with.

The arrangement for raising and lowering the ram G will be seen in Fig. 4, where the hand-wheel N, having on its shaft a worm gearing into the worm wheel O, on the shaft of which is the pulley P, carrying two chains (see Fig. 3), one fastened to the top and the other to the bottom of the ram, the chains being kept tight by two lock nuts.

A brass collar Q fits the ram G (Figs 3 and 4), and when adjusted and secured by a set screw indicates to the moulder when the segment V is lowered to its correct depth. The eye-bolt W screwed into the top of the spindle C, is for hoisting the machine by the crane.

Having described the parts of the machine, the process of moulding a wheel by it will now be detailed. First, the pattern maker will prepare a core box for the arms of the wheel; secondly, two radial boards for strickling the form of the face and back of the wheel in the sand; thirdly, a segmental pattern of the teeth.

The two boards required should represent the exact shape of the face and back of the wheel over all, thus, by Fig. 5, showing the boards used for a bevel wheel, and also by reference to Figs. 6 and 7, representing those of a spur wheel, it will be seen that the board *l*, called the top board, has on its lower edge the form of the back, and the board *m*, called the bottom board, has on its upper edge also the profile of the back fitting accurately the outline of board *l*, and has also on its lower edge the profile of the face of the wheel. The segmental pattern consists of two teeth of the wheel required, allowing one space to mould with, as seen in Fig. 4.

Having decided upon the most suitable place in the foundry to work the machine, a hole will be dug in the floor of sufficient depth to allow the top of the pedestal A to be from the surface of the floor a distance equal to the greatest breadth of wheel that the machine will mould. It is well also to secure the pedestal in the ground by attaching to it a plate, as seen in Fig. 5, which presents a good area upon which the sand may be rammed, and so making a firm and steady centre; then when the spindle B is put into the pedestal, and the rest of the apparatus on B, the machine will be complete, as seen in Fig. 4. But it is necessary at first to have only the spindle B in the pedestal, as in Fig. 5, the rest of the apparatus being placed aside for the present. The first thing the moulder has to do being to prepare the bed of the wheel and to ram the top box or other arrangement used to cover the wheel. To do this he fixes on the spindle B the correct level of the bed or face of the wheel measuring from the floor level a distance equal to the breadth of wheel required, at which point, if needed, he places either of the loose collars as in Fig. 5, where the collar *x* marks the level by its top edge; he also places on the spindle B a second collar *y*, Figs. 5 and 6, the top edge of which marks the top or back of wheel; this latter collar *y* is secured to the spindle by set screws.

This being done the top part will be prepared first, and to do this sand is heaped to the level of the top of the collar *y*. The iron trammel S, with the top board *l* attached, is placed on the spindle B, bearing on the collar *y*, and being moved round will strike the impression of the top or back of wheel, and also provide the joint between the two parts by the projecting edge of the board. When this impression is finished by the ordinary way of strickling, it is sprinkled with parting sand and an ordinary top box or other sufficient covering placed over it. Sand is then rammed in, and the position of the box staked. It is then lifted away, carrying with it the form of the back of

the wheels, and being turned over, it can be finished by means of the second trammel T, and board *m*, which has on its top edge the profile of the back for this purpose. A loose centre is provided for use in the top part.

The top part being thus produced, the sand is cleared away to the level of collar *x*, being the level of the bed or face of the wheel. The collar *y*, and trammel S, will then be removed, and the trammel T, with the bottom board *m* attached, placed on the spindle B bearing on the collar *x*, Figs. 5 and 6, and being moved round the shape of the face and angle of the teeth will be obtained. The moulder by the ordinary process of strickling will finish the bed, making it ready to receive the teeth and cores for the arms and boss, which being done, and the trammel T removed, the rest of the machine will be placed on the spindle B, as seen in Fig. 3, care being taken that the set screws in the spindle be fairly secured, thus maintaining the separate spindles as a continuous axis through the machine.

The segment V must be fitted perfectly square and central in the angle bracket; M being attached with screws; the radius of the required wheel must also be set by means of the screw L, Fig. 4, measuring from the top of the tooth to the centre of the machine. The proper change wheels will also be secured in their places, the numbers required being found on reference to a wheel list supplied.

The moulder will now lower the ram G with the segment to the level of the bed, Fig. 3, by the raising and lowering arrangement, and at this point the brass 2, Figs. 3 and 4, is secured, ensuring the segment always reaching an uniform level. In bevel wheels the hand screw R, is also secured at this point, holding the ram against the upward pressure of the ramming.

The moulder will now proceed as is usual by putting sand into the space, and ramming it sufficiently solid. He will thus form one space, which being done, he will draw the segment from the mould until clear of it by the raising arrangement described. He will then move the segment the exact distance required to form another space by the dividing arrangement of the handle, shaft, change wheels, worm and worm wheel as already noticed, the trammel carrying the dividing gear causing the segment to revolve on the central axis the exact portion of the circumference required. The moulder will then lower the segment again and proceed as before until the requisite number of teeth are completed, which being accomplished, the screws in the spindle are loosened and the crane by the eye bolt W, will lift the apparatus away. The spindle B will also be withdrawn leaving the bed with the teeth perfectly clear to receive the cores for the arms and boss.

The hole in the pedestal is fitted with a cover to keep out the sand when the spindle is withdrawn. Sand is then filled in on the cover, acting as a protection to the pedestal. The core for the boss is then adjusted as usual from the circumference, and the cores for the arms set to their places by wooden gauges showing the thickness of the arms and rim. These being completed the top box is brought and adjusted by the stakes to its exact exact place. The runner is made, the kox weighted, and the mould is then ready to receive the metal.

The result of this mode of moulding must be a wheel of excellent construction, as the trammel revolving on the central axis compels a true circumference, and the dividing arrangement, the correct relative position of the teeth; the raising motion, a slow steady withdrawal that leaves the tooth perfectly finished; the segment, having but one space, produces each as a duplicate of the others. The machines are made to mould spur, bevel, or mortice wheels to any diameter.

In the Russian department we found a machine for moulding hollow shot constructed on the same principle as that described for the moulding of the outside of pipes; the two halves of the shot are moulded on one table, the models projecting through corresponding openings in the table plate. They can be raised or lowered at will by means of a crank lever. The moulding boxes are put over the patterns and are filled with sand through openings in the back; they are fastened to the table plate by means of pins, which not only secure their proper position on the table, but also serve as guide pins in connecting the two halves of the mould together. The whole arrangement is very ingenious, and could be used with success for many similar purposes.

We now come to the review of those castings in which the strength and

tenacity of the material employed is the main object. The principal representatives of this sort of castings are cast-iron guns and chilled cast-iron shot. The very best material only can be used for both articles. In accordance with this fact, we found an efficient and noteworthy manufacture of cast-iron guns and shot being carried on only in Sweden, Austria, and Russia, the only countries except America where ores of such purity are found as to enable charcoal pig iron of sufficient tenacity and strength to withstand the enormous pressures and shocks the above-named articles have to sustain to be successfully manufactured.

The excellency of Swedish iron promoted its use for the manufacture of guns and shot long ago, and the exhibits of this country show results which, though not surprising to those interested in this branch of human murdering industry, are nevertheless striking in every respect when compared with those obtained in other countries.

Gun iron, as we may be allowed to call this sort of iron used in the manufacture of guns and shot, is at present only produced in two places at Sweden, at the iron works of Ankarsrum and Finspong, the latter place containing the gun factory, while chilled shot are manufactured at both works.*

The gun manufactory of Finspong was put to work in very remote times, and was bought in the beginning of the 17th century by a Dutchman named Louis de Geer, who enlarged the works, and whose family kept the whole estate until 1856, when it was bought by a Swedish ironmaster. The iron used at present for guns and shot is obtained from the mines at Förola, Nartorp, and Stenebo. Förola yielding the purest ore has 80 per cent. in the mixture, while 10 per cent. of Nartorp, and 10 per cent. of Stenebo ores are added. We give in the following Table the analyses of these ores:—

Composition of Ores from the Mines of Förola, Nartorp, and Stenebo.

Constituents.	Förola.		Nartorp.	Stenebo.	Remarks.
	Uncalcined.	Calcined.	Uncalcined.	Calcined.	
	1.	2.	3.	4.	
Magnetic iron ore	69·1	77·1	64·4	75·5	
Protoxide of manganese	0·24	0·48	0·17	0·38	
Copper, Cobalt	0·12				1. Analysis made by C. H. Lundström, 1870.
					2. Analysis made by C. D. Tidström, 1858.
Phosphorus	0·009	0·61	0·016	0·03	3. Analysis made by A. T. Groth, 1860.
Sulphur	0·145	0·06	0·07	0·09	4. Analysis made by M. Björkmann, 1858
Contents of metallic iron	69·614 50·1	77·65 55·9	64·646 46·6	76·00 54·7	

The slag-forming constituents contained in the above-named ores, consist of the following parts :—

Slag-forming Materials; Förola, Nartorp, and Stenebo.

Constituents.	Förola.		Nartorp.	Stenebo.
	Uncalcined.	Calcined.	Uncalcined.	Calcined.
Silica	79·0	90·6	57·5	80·4
Alumina	3·8	4·2	2·8	9·6
Lime	4·7	2·6	32·1	3·2
Magnesia	11·7	0·4	7·1	5·2
Protoxide of manganese	0·8	2·2	0·5	1·6
	100·00	100·00	100·00	100·00

*See Section XVII.—Ordnance.

These ores are smelted in charcoal blast furnaces with *cold* blast. The pigs are carefully classified according to their degree of hardness, and remelted for use in reverberatory furnaces.

The iron tapped from the reverberatory furnace, where it undergoes a purification and a decarburisation to a certain extent, is by far stronger than the iron tapped directly from the blast furnace, and has the following composition :—

Silicon	0·48
Graphite	2·05
Carbon	1·41
Manganese	0·25
Sulphur	0·13
Phosphorus	trace
Aluminum	—
Calcium	—
Copper	trace
Iron (loss)	95·68
	100·00

The specific gravity of this iron varies from 7·30 to 7·45.

The guns of 6 in. bore and upwards are cast with the mouthpiece uppermost and the hollow core fitted with a syphon. During a certain time after casting, the bore is cooled by atmospheric air introduced into the syphon, and after the removal of the core the inside is cooled by water. The smaller guns are cast solid. An admirable mode of testing the material of each cast, worthy of imitation, is used at Finspong. At every casting a small gun of 4 lb. or 6 lb. is cast at the same time, and of the same molten material from the reverberatory furnace as used for the real gun. This diminutive gun is then tested to rupture, and in this way gives reliable data as to the quality of the mother gun. Several of the large guns, from 4·76 in. bore upwards, have cast-steel rings shrunk on the main cast-iron tube.

Finspong exhibited a large cast-iron breech-loading gun of 9·44 ins. diameter of bore, armed with steel rings. This gun has fired 330 rounds, with 52·8 lb. to 57·2 lb. of powder, and a cast-iron shot of 316 lb. The gun is in a perfect state, and fit for further service. Besides several guns of smaller calibre, a field gun was exhibited cut through parallel to its axis to show the diminutive alterations the bore has undergone after a very severe trial. This gun, of 3·77 in. bore, weighing 1,400 lb., has a maximum thickness of metal of 1·105 calibre, whereas the minimum thickness is only 0·17 calibre—weight of shot, 17·16 lb. This gun fired 1,200 rounds, with 2·42 lb. of powder charge, and 100 rounds, with from 2·86 lb. to 3·3 lb. of powder, and, with the exception of an early insensible enlargement of the powder chamber, shows no signs of deterioration. In the Finspong pavilion we found a cast-iron ring of 30 in. diameter, about 9 in. broad, and $\frac{3}{10}$ in. thick, of great elasticity and strength, showing the excellent quality of the material.

With all this the price of the Swedish guns is exceedingly low. A breech-loading cast-iron gun of 9·44 in. bore, armed with cast-steel rings, and weighing 14·766 tons, costs not more than 31,000 francs, or 1,240*l*. The price of muzzle-loading guns of 4·8 in. bore, weighing 4,100 lb., is only 3,100 francs, or 124*l*. Field guns of 3·77 in., 3·03 in., and 2·71 in. bore, weighing 1,400 lb., 836 lb., and 550 lb, respectively, are costing now 580, 430, and 380 francs, or 23*l*. 4*s*., 17*l*. 4*s*., and 15*l*. 4*s*. a-piece. These guns could not be got at the Austrian gun factory of Mariazell under 36*l*., 28*l*., and 24*l*. respectively.

As to the material of the chilled cast-iron shot of Finspong and Ankarsrum, we can only state its excellence. In 1869 a series of trials were made at Finspong with ogival chilled shot. The target was composed of six layers of wrought-iron plates, the total thickness of the iron armour being 30 centimetres (11·8 in.), backed with wood. This target was completely perfo-

rated with great facility by shots of 9·44 in. diameter. The shots were found to have not been injured at all; not the slightest cracks were to be detected, and the points of the shots were as good as before the trial. After this the target was reinforced by a massive plate, thus representing a total thickness of 43 centimetres (16·9 in.) of iron. This target was strongly indented by the same kind of shot, but the latter fell back without perforating the plate. The shot did not show any signs of deterioration except three fine fissures on the ogival part. In Denmark similar trials took place, and there the Finspong chilled cast-iron shot of 11 in. diameter perforated with ease an 8 in. armour plate backed by 18 in. of teak.

In Austria, where excellent iron for ordnance is produced, the guns are cast solid, care being taken to let the casting cool very gradually. The pig iron for ordnance is melted at Mariazell from spathic ores found in the vicinity, and limestone containing about 20 per cent. of sesquioxide of iron and a small proportion of graywacke are added as fluxes. The analyses of the ore and fluxes are given in the following table:—

Constituents.	Spathic Ore from Gallrad, calcined. Analysed 1869.	Fluxes.		Remarks.
		Limestone from Rothdahl. Analysed 1869.	Graywacke Slate. Analysed 1869.	
Protoxide of iron	1·79	—	—	These analyses have been made by the Imperial Laboratory, Vienna.
Sesquioxide of iron	65·64	20·66	7·22	
Protoxide of manganese	3·22	2·16	1·16	
Lime	1·30	34·05	2·90	
Magnesia	9·43	2·55	0·83	
Alumina	2 36	3·89	15·66	
Silicia	15·44	5·30	66·60	
Carbonic acid	2·50	31·00	5·63	
Sulphuric acid	0·29	0·10	—	
Phosphoric acid	0·12	0·11	—	
Black oxide of copper	0·02	—	—	

The ore is melted in charcoal blast furnaces with coal blast. The iron produced contains:—

Silicon	1·671
Graphite	2·416
Carbon	0·936
Manganese	3·080
Sulphur	0·016
Phosphorus	0·062
Aluminium	—
Calcium	—
Copper	0·100
Cobalt	0·083
Iron (difference)	91·636
	100·00

In comparing this analysis with that of Finspong, we find the amount of carbon to be nearly the same in both cases, only the proportion of graphite predominates in the Mariazell iron, while the latter contains much more manganese than the Finspong iron (3·08 against 0·25). This great difference is very striking at first sight, but by closer investigation it seems that this large amount of manganese in the Mariazell iron is necessary to counterbalance the impurities which the latter contains in greater proportion than the Swedish cold blast iron.

The slag produced by the manufacture of this iron contains:—

Silica	43·35
Alumina	5·50
Lime	15·96
Magnesia	29·83
Protoxide of iron	0·90
„ manganese	2·70
Sulphur	0·23
Phosphorus	—
	98·47

The tenacity and strength of the Mariazell iron from cold blast, when remelted in a reverberatory furnace, is very great, its ultimate breaking strain being 17½ tons per square inch on an average.

Cold blast iron tapped directly from the blast furnace was tested in 1870 to 20 kilogrammes per square millimetre, or 14 tons per square inch. Samples of American cold blast charcoal iron exhibited by the Atlas Works Company, Pitsburg, have been tested, and found to break with a strain of 24,270 lb. per square inch, or about 16 kilogrammes per square millimetre.

There is no doubt that cast-iron can be had of the most perfect quality, and if properly treated will stand any reasonable test. Having gained a good deal of experience in this branch, especially in the manufacture of cast-iron guns of very different calibres, we may express our opinion to the effect that in spite of its comparative toughness and adaptability to sustain heavy concussions without injury, its employment in the construction of heavy ordnance, limited as it is at present, will be entirely abandoned. Leaving, however, the discussion of this question, we will close the review of gun and chilled shot castings with the statement that the Reichenaur Iron Company, working the mines and blast furnace at Edlach and Reichenau, near the Semmering, on the frontier of Styria, exhibited some fine examples of chilled cast-iron shells, one of which, 9 in. in diameter, has perforated an 11 in. armour plate, three or four small cracks at the beginning of the ogival part being the only sign of the heavy concussion. In Russia cast guns and shells are manufactured at the Imperial Iron and Steel Works of Perm, which exhibited a natural section of the muzzle of one of the 20-in. guns cast at the works, showing the perfect soundness and compactness of the casting. A cast-iron shell, 11 in. in diameter, of the same origin, was exhibited after having perforated an 11-in. armour-plate without any sign of deterioration except that a small piece of the point has been carried off.

Malleable castings have now been largely introduced on the Continent, and we found, consequently, very good exhibits of such castings in the French, German, and Austrian departments. We must look upon this industry as a very young one, which, though the principle upon which it is based, was known long ago, has only of late years became a commercial success. There are so many opportunities for using malleable-castings instead of wrought-iron forged articles that we can only encourage the manufacturers to extend the application of these castings to a greater variety of objects than those exhibited in Vienna. We need only mention the great number of forged articles wanted for the construction of road and railway carriages which would present a very remunerative manufacture. Among the exhibitors of malleable castings we may mention Messrs. H. F. Eckert, of Berlin, Reunerta and Co., of Witten a. d. Ruhr, Hardy Capitaine and Co., at Nouzon, Ardennes, and several others in the Austrian department.

This review of malleable castings closes the report on castings in general, and leads us at once to the next subject, namely, "art castings," which forms a distinct branch of itself, and which is dealt with in the following division. We may add, however, that in treating of art castings we shall have occasion to point out some facts connected with the selection of metal and moulding sand, which are almost equally applicable to the production of other castings.

Art Castings.

The Ilsenburg Iron Works are amongst the oldest in Germany, and the iron foundry there is most probably one of the earliest in the would. In ancient documents written in the fifteenth century, pots, plates, balls, &c., cast at Ilsenburg, are mentioned; while cast-iron plates which have been collected on the spot for some time past afford additional evidence on this point. The director of the Ilsenburg Foundry, Oberhütten Inspector Schott, has collected and arranged these plates in his official residence, and the collection possesses much interest, not only from an historical, but also from an artistic point of view. All these plates have served as stove plates, and almost all are marked with a date, the earliest being that of the year 1509. The subjects on the plates are chiefly taken from the history of the Bible, and the ornaments consist of busts, tournaments, and allegorical pictures. The latter begin with the commencement of the seventeenth century. Some of the older plates are very beautiful, and the whole collection proves in the best possible manner the high position German art must have occupied in the 16th century, how it declined gradually during the thirty years' war, and how it finally died out utterly during the 18th century.

While the earlier productions show the most originality—for instance, Judith in the tent of Holofernes, surrounded by guns and gabions—the design of the figures, dresses, &c., is likewise so satisfactory from an artistic point of view, that the pattern-makers of that time who carved the models (some of which are still at the stores of the foundry), must have been men well skilled in their art, and must have attained a degree of perfection which has never been since reached. But the success did not rest with the skill shown in the pattern, the moulder using the pattern evidently participated in it, otherwise such fine castings could not have been produced.

With the decline of skill in making the patterns, the taste naturally became corrupted, and the moulding less and less perfect, until eventually it lost all artistic value; and even in the beginning of the present century the art of moulding still remained in a very primitive state. When the taste for artistic design began to revive, the hands, still rough and unskilful, were led to better and higher-class productions, which elevated the taste. When the appreciation of elegant forms shall have become general, then, and only then, we shall have in all branches of industry products equal to those of the 16th century, and the debased taste, now too common, will gradually disappear.

The necessity of extending the influence of art to all departments of iron industry occurred, nearly 40 years ago, to Mr. Schott, who was at that time engaged on the Brunswick Works, the Carlshütte and the Wilhelmshütte, works still famed for the excellency of their foundry productions. Mr. Schott is now, and has been for 35 years, the managing director of the Ilsenburg foundry, and from the first he sought to cultivate art in the productions of the works. The highly satisfactory results of his exertions in this direction were shown by the exhibits of castings of works of art in the German annexe for art and industry, at the Vienna exhibition.

The Ilsenburg Foundry exhibited at the Vienna Exhibition art castings representing chiefly objects of the Roman period, of the middle ages, of the Renaissance period, and generally of such well-known works produced by master-hands as are most suitable for reproduction in iron. These castings are worthy of all praise for the clearness of the castings, and especially for beauty of form. They are not only suitable for decorative purposes, but they are very instructive.

It is unfortunately but too true that the want of appreciation has caused numerous works of art to be destroyed. Even in the first half of this century it has happened that ancient church vessels have been sold by the authorities for the value of the metal for remelting. Such vandalism, however, is now no longer possible, and objects of art are sought for, and carefully preserved. How much art education has progressed in this direc-

tion has been fully proved by the many collections which have been made during the last few years. With refinement of taste increasing demands are made on precision and correctness of execution, and public taste has become greatly refined. Imitations and reproductions of antique works of art are no longer accepted if merely simple copies of the outer forms, but an execution is demanded which shall exactly represent the original in the smallest detail.

In consequence of the scrupulous exactness with which the old masters executed their work, an exactness which did not admit of neglect even in the smallest and least important detail, great difficulties are met with in the reproduction of such works of art—difficulties which are especially great in iron castings on account of the impossibility of the parts being united by soldering. But notwithstanding these disadvantages, the problem has been solved, and that in such a manner that iron castings may be substituted for electrotype productions, combining, as they do, greater strength with equal fineness, while being cheaper, they should certainly be preferred. These are results which have been achieved through continued exertions with the view of cultivating pure art in the production of iron castings, and it is very desirable that these exertions should be continued by future ironfounders.

With regard to the process of production it may be observed that the two main points upon which the casting of iron depends are the moulding sand and the metal. About 500 or 400 years ago the conditions for preparing the sand required for casting upon the open hearth must have been known. It must even then have been recognised that the moulding sand should allow of the penetration of the expanding gases which are produced by the high temperature when the fluid metal is poured into the moulds. Otherwise the fine castings already referred to could not have been produced. This condition of the moulding sand was far better understood in this remote period than at a later time, when an empirical preparation of the sand was considered to be sufficient, a state of affairs by which progress in the art of casting was necessarily hindered. When the question had to be decided as to what was to be done to improve the sand, especially for the production of sharp and fine castings, it is probable that a greater degree of fineness was tried. Unfortunately this condition of great fineness, which is decidedly necessary for sharpness in the castings, was accompanied by the disadvantage that the fluid metal, when poured into the mould, did not remain undisturbed, but destroyed the work of the moulder. The problem was to find an explanation for these occurrences, and an acquaintance with the principles of the open hearth doubtless led to the conclusion that the want of penetrability produced by the great fineness of the sand, gave rise to this bad result. Nature rarely supplies a moulding sand which possesses both finenesses and penetrability, and the general scarcity of such a sand, which induced many important iron foundries to obtain it at great expense from distant places, naturally led to artificial productions being tried. We propose now to explain the experiments made for producing an artificial moulding sand, and the results obtained.

Moulding sand.—Of the various kinds of moulding sand at the disposal of the Ilsenburg Foundry, one is found in the neighbourhood, in the diluvial formation, this sand consisting of a mixture of fat loam with coarse grains of quartz. It is used for the moulding of large castings, and the moulds made of it can be employed only after having been dried at a high temperature. A rather finer variety of this sand serves, when mixed with other sand, for a certain class of castings; but in this case, also, it is necessary that the prepared parts of the moulds should be dried or heated in order that by the evaporation of the water there may be produced a contraction of the proportion of clay which the sand contains, and that thus there may be formed the minute channels which are necessary for the escape of the gases and steam generated at the high temperature of the fluid iron.

In the chalk formation, which fills the large and, in some places, deep basin adjoining the mountains of the Harz district, there are found in the neighbourhood of Ilsenburg, upon the chalky marl, strata of loam mixed more or less with grains of quartz of different degrees of fineness; the

penetrability, and thus the utility of the moulding sand depending upon this admixture. In a few exceptional places there is found a moulding sand that could almost be used in its natural state; the quantities thus obtained, however, are very small, and are not in proportion to the increasing demand of the Ilsenburg Foundry. If, therefore, the artificial preparation of the moulding sand had not been successfully introduced, the necessary supply could only have been obtained from distant sources at great expense.

After having recognised the penetrability of the sand for steam and gas as the chief characteristic necessary, it became next an important matter to determine the signs of this required penetrability existing, and for this purpose the following process has been adopted: A known peculiarity of a sand which allows of a casting being made in it without the mould being artificially dried, is, that if the mould is moistened with water, the sand possesses the surprising quality of absorbing the water without altering the mould. The moulder can thus, when working with the so-called green sand, employ water according to his requirements, in order to strengthen the sharp corners, edges, and ribs of the moulds, for which purpose water may be dropped upon the latter by means of a brush. The water disappears, and is absorbed without doing any damage to the mould. This quality of the sand has been turned to account at Ilsenberg in the following manner for determining the penetrability of the material. After various mixtures of sand have been prepared, and after it has been ascertained that sharp and distinct impressions can be taken with the materials, equal sized balls or cubes are formed by compressing the sand in the hand, and that to such an extent that a slight further compression is just possible; this is easily done with a little practice, and this manipulation forms an important factor in ascertaining the quality of the sand for all moulders, and determines the degree of moisture to be given to the moulding sand for casting in a green state. The balls of sand thus prepared and made of uniform size, are then weighed, and water is next poured upon them, as long as it is absorbed. When absorption no longer takes place, and the water appears to remain on the surface of the sand, the balls are weighed again. Supposing the different samples to be equaly good, as far as the power of producing sharp impressions (as previously ascertained) is concerned, then that sample which is capable of absorbing the largest amount of water will offer the greatest facility for the escape of the gases and steam.*

It was in 1844 that, by the kind recommendation of the director of the Ecole des Mines at Paris, M. Le Play, the professor Gaultié de Chaubri obtained for several professional men admission to some of the foundries of Paris. Excellent moulding sand was to be found there, and the qualities which it possessed necessary for the production of good castings could be studied. The experience gained from the continued casting of bronze works which could be applied to iron castings, and the great advantage possessed by these foundries of having to work only for specialities, and of not having, like other foundries, to change the class of work to be done every day, exercised a great influence upon the gradually improved preparation of the suitable sorts of moulding sand.

Even in Paris it was impossible to get from natural sources a sand that would fulfil all requirements, although remarkably good sand is easily obtained there. Only a few districts of England and Germany participate in this advantage, and the neighbourhood of Halle-on-the-Saale and of Walkenrind, in the Harz mountains, should especially be mentioned in this respect. It thus became necessary, even in Paris, to prepare good and useful sand, by artificial mixture. Four different sorts of sand, two of a reddish and two of a greyish-yellow colour, were found to be applicable for casting in green sand. A variety of sand similar to the latter was found in exceptional instances in the neighbourhood of Ilsenburg, but as mentioned already, it

* It should be mentioned here, that in examining the varieties of sand, care has to be taken that the latter does not contain lime, which is often the case when the sand is found to lie on marl, hence the greatest care should be taken in obtaining the material. The burning of the lime, which takes place at the high temperature of the iron, forces the carbonic acid to escape, disturbs the fluid iron, and prevents the exactness and clearness of the casting. It is, therefore, desirable before using the sand to examine the amount of carbonic acid contained in it, by pouring upon it sulphuric acid.

could only be obtained in an insufficient quantity, and not of quite as good quality as that found at Paris. Comparing the Ilsenburg sand with the samples obtained from Paris, it was found that the former was deficient in the contents of fine grains of quartz, whence its penetrability was not the same as that of the Paris material.

The treatment above referred to of the sand consisting of a mixture of fat loam and coarse grains of quartz, the insufficient penetrability of which had to be increased by continued drying or roasting, had therefore to be applied also to the fine sand, and it had to be ascertained whether the deficiency in the contents of grains of quartz could not be compensated for by the roasting of a part of the denser sand, which was consequently exposed to such a high temperature that the yellowish-grey colour was changed into red. The mixture of this roasted sand with the original yellow-grayish sand, in its natural state, gave the desired result, and the roasted sand was found to be a perfect substitute for the grains of quartz in which the natural sand was deficient. In order to make, however, this artificial mixture equal to the natural material, a careful treatment was necessary, and for this purpose stamping mills and revolving drums of oval section, containing loose balls, were adopted for the powdering and mixing of the sand. These drums have a diameter of about $3\frac{1}{2}$ ft. and a length of not more than about 4 in., whilst the speed of rotation is arranged in such a manner that the balls are not so acted upon by centrifugal force as to prevent them from remaining at the bottom of the drum, or they would not exercise the necessary pressure upon the sand which is put into the drum through an opening at the side. In order to obtain the required fineness of the sand, the passing of it through fine meshed sieves becomes necessary, and for this purpose bolting cloth made of sheep's wool, and known in Germany under the number 16, has been found best.

A fine moulding sand applicable for most castings in green sand was thus successfully produced, but the finer and better sorts of a reddish colour seen and found at Paris, which possess an extraordinarily high amount of penetrability, and which, moreover, allow of the cleanest and sharpest castings being made, were still wanted. It had been especially observed that the castings in this sand, which was even moistened to a great extent, remained unusually undisturbed, and it became, of course, a natural necessity to possess a moulding sand of equal quality.

At first an endeavour was made to discover such a sand in a naturally loose state, and it was thought that it might be found in the intermediate layers of the coloured sandstone formation met with on the outskirts of the Harz mountains. All the sand, however, that could be found in a loose state in these strata contained too much clay to afford the required penetrability. Even after roasting it was found to be useless, because it had lost all its binding power, and attention was then directed to the solid sandstone, which, when ground, was expected to supply material of the necessary quality. The experiments made with this solid stone showed such a great penetrability that the best results were obtained. The experiments with water pointed fortunately to a certain class of stones which had to be rejected for building purposes on account of their extraordinary hygroscopic qualities; these latter, however, justified great expectations for the moulder—expectations which have now for many years been entirely fulfilled. The mixture of the sand obtained from the stone, with the yellowish-grey sorts of sand mentioned above, has produced an exceedingly suitable moulding sand, the moulder having it in his power by adding more or less of the ground stone, to vary the quality of the material in accordance with the requirements of the work he has in hand.

The knowledge of the proper class of moulding sand required for a given pattern, is the best proof of the ability of a moulder, and such a knowledge can only be acquired by extended practice and correct advice, which latter, however, is unfortunately very often wanting in foundries producing inferior work. The importance of the correct preparation of the sand is in general little appreciated, and so long as no proper attention is paid to the requirements of a good moulding sand, and as long as there is wanting a correct understanding of the required penetrability in connexion with a consistence

of the material sufficient for the finest impressions, iron foundries will turn out works of art which cannot be appreciated by eyes which have had opportunities of getting acquainted with more perfect productions.

From what has been said above, it will be found that the excellence of the moulding sand to be used does not depend so much upon the chemical composition, but rather upon the mechanical and correct mixture of the argillaceous and silicious components. If the chemical investigations made in Paris and London with the small parts of mouldings and that remained at those places on the castings exhibited by Ilsenburg, had been ever so carefully performed, they could scarcely have led to the preparation of a suitable moulding sand, which depends simply upon the shape and size of the added grains of quartz, and the plastic qualities of the clay.

In the course of years a special custom has often taken root in foundries, in consequence of which most extraordinary results are often produced. The practice acquired in the manipulation can go so far, for instance, that a sand possessing a very small amount of binding power, but a high degree of penetrability—a class of material often found in nature—is used with the best results. The ability acquired to produce fine castings in a loose sand which gives way to the smallest shaking, which possesses only so much consistency as is required to withstand the pouring in of the fluid metal, and which combines the advantage that the large proportion of grains of quartz prevents a burning of the iron, and produces better castings requiring only little cleaning, is a great gain, which saves many expenses incurred by the employment of a moulding sand of greater binding power.

Quality of the Metal.—Art castings in iron require for their successful production a carefully chosen metal, one which must not only possess greater strength than is required for ordinary castings, but one which, by its density and fluidity in a molten state, is capable of reproducing minute forms with sharpness and exactness. In order to obtain definite information as to the conditions under which suitable iron is produced by the smelting process, the material has, at Ilsenberg, been subjected to careful examination, both when in the fluid state and during the progress of setting and cooling; and these investigations, which have been carried on for more than 30 years, have resulted in the discovery of the facts of which we propose now to speak—facts which are of high interest in themselves, and which appear to us worthy of the most careful attention of metallurgists. Some time ago we called attention to the appearances which cast iron assumes during the fluid state, these appearances varying according to the proportion of carbon which the material contains, and even as long ago as 1867 there appeared in *Engineering* (in an article entitled "The Berlin Castings"—a name formerly generally used for art castings in iron, but now almost abandoned) an account of these appearances. The matter did not, however, at the time receive from scientific men the attention it undoubtedly deserves, and we therefore propose to deal with the subject here, and to discuss it more fully.

According to the appearance of the new fracture when broken, pig iron is, and has been for many years, both in this country and abroad, designated by certain numbers, the particular value attached to each number varying, however, in different localities. Speaking broadly, No. 1 signifies a coarse-grained dark-grey iron, Nos. 2 and 3 are finer grained and lighter greys, whilst beyond these come the "mottled" and "white" pigs. In many foundries in Germany the following scale is adopted:—No. 1, largest grained highly graphitic grey pig (*Gaares Eisen*); No. 2, grey pig (*gaarflüssiges Eisen*); No. 3, mottled pig (*halbirtes Eisen*); No. 4, strongly mottled pig (*stark halbirtes Eisen*); No. 5, lamellar pig (*dünngrelles Eisen*); No. 6, dead-white iron (*hochdunnes Eisen*); and No. 7, white pig (*grelles Eisen*). In this classification—which we shall adopt hereafter in speaking of the appearances of the different classes of molten iron—Nos. 1 and 2 are varieties of grey iron, Nos. 3 and 4 of mottled iron, and Nos. 5, 6, and 7 of white iron.

If now an alteration in the working of the blast furnace or of the cupola, shows that a change has taken place in the quality of the iron, or if it is

desired to secure the success of a particular casting, the following observations may advantageously be made. Let a sample be taken from the iron available, and let it be cast in a hemispherical mould prepared as for an open sand casting, but lined with finely prepared sand, care being taken that the sand is neither too tightly or too loosely pressed down. For making this simple casting a small ladle and a straight-edge are carefully warmed, and the necessary quantity of iron is then tapped from the furnace or cupola into the ladle, the slag being removed with the heated straight-edge. When this has been done the iron is poured out as quickly as possible into the mould, when the heated straight edge is again passed over the iron. Experience has shown that when a furnace is working irregularly the various classes of iron above spoken of are sometimes to be found arranged one over the other, according to their specific gravities, and in procuring a sample, therefore, care should be taken to procure an average of the whole. The metal having been poured as above directed, the following observations should be made :—

1. The colour of the iron during the casting.
2. The movements which take place upon the surface of the metal immediately after pouring.
3. The state of the iron during and after its setting.

For the various classes of iron above enumerated these appearances will be as follows:—

No. 1 *Iron.*—This iron has during the casting a reddish-white colour, and after running it remains unagitated, and has the appearance of a crystallized fat, while it presents a frothy surface covered with "kish."* Its fracture when cold is dark grey, coarse-grained, glossy, and very soft; but when re-melted it gets a finer structure, and becomes suitable for being re-cast in crucibles for the production of art castings. The sketches *a*, *b*, and *c*, Fig. 14, Plate XXXIII., show respectively the form of section of this iron when cold, its appearance when in the fluid state, and its outside surface.

Another variety of this iron is represented in section when cold by the sketch *d*, Fig. 15, while its appearance when molten is shown by *e*, and its outside surface by *f*. During the pouring, this metal has a lighter colour than the variety of No. 1 previously mentioned, while, when cast, its surface is covered with a thick dim skin, which during the experiment slowly separates in one direction in straight lines, showing at the fissures the bright metallic surface. After these movements have lasted some time, the dim skin again entirely unites, while the iron is seen to be still agitated, and commences to show small projections at those points where the division of the skin last occurred. After setting the iron shows a slightly convex surface, which has a smooth glossy appearance, with here and there a sparkle of graphite.

This iron when cold has a dark grey glossy fracture, the grains in the latter being the more strongly marked, the greater the volume and strength of the casting. This class of material is well suited for the casting of fine works of art, as when quickly poured it fills the moulds well and perfectly, possessing at the same time a great amount of softness. When less quickly poured the separation of "kish" gives to the casting an objectionable appearance similar to that of the first-mentioned variety after setting.

No. 2 *Iron.*—Of this iron we also give three sketches, Fig. 16, Plate XXXIII., that marked *g* showing the form of section of the sample casting when cold, whilst *h* represents the appearance of the metal when in a fluid state, and *i* its external appearance when set. This iron has during the pouring a dazzling white colour, while the dim skin which forms on the surface does not appear to be so thick as in the case of the class of iron last spoken of. As the iron runs from the ladle, a tearing asunder of this skin, and a display of a metallic glare below is observed, the surface at first splitting only in one direction, but fissures subsequently opening up in various directions ; the sketches *k* and *l*, Fig. 17, Plate XXXIII., showing the chief figures formed. The figure *k* refers to a charcoal, and figure *l* to a coke, iron. These figures may be traced

* For the difference between graphite and "kish" see a paper contributed by M. Ledebur o the *Berg und Huttenmännischen Zeitung.*

even after the setting of the iron, they being then formed by projections on the surface. After the fissures on the surface have been drawn together again, the iron which is still agitated beneath evolves small bubbles of gas, which force their way to the surface, this being especially the case towards the middle of the mass.

With the exception of the points where projections mark the last fissures in the skin, the surface of this iron when set is dim, glossy, and smooth, and its appearance is similar to that of refined metal, this being the case even in the fracture, with the exception of a little lighter colour, and slightly denser structure. This iron is the best for art castings, as the largest as well as the smallest articles may be safely cast from it, it giving clean and sharply marked productions, which can be well worked on account of their but slight degree of hardness. If also the blast furnace charges are good, and the varieties used in the cupola well chosen, iron of this class shows great flexibility and elasticity.

No. 3, *or Slightly Mottled Iron.*—This iron has, when poured, a light or white colour, the skin being similar to that of the No. 1 iron, but thinner, while at the point where the flowing commences a stronger metallic lustre appears on the broken surface. In the sketches Fig. 18, Plate XXXIII., *m* shows the section of this iron as set when cold, *n* its appearance in a fluid state, and *o* its surface when cold. After the pouring has taken place, the iron at first like that last-mentioned shows fissures in the skin extending in one direction only; but this merely lasts for a short time, a dividing of the lines then taking place, and cruciform fissures being formed for charcoal, and starlike fissures for coke iron, as shown by sketches *p* and *q*, Fig. 19, respectively.

This splitting up of the surface into figures goes on very rapidly, new figures continually appearing only to disappear again and make room for others, the appearance being altogether a very interesting one, while the to-and-fro movement in the material is remarkable. After this state of affairs has lasted some time the evolution of bubbles of gas commences, the bubbles being more numerous, and being evolved with greater activity than in the cases formerly noted. During this period a great agitation of the metal occurs, this decreasing gradually until the iron is "dead," when it begins to set. The surface is in this case no longer rounded but straight, and is covered with a number of small spheres, which show empty hollow spaces, and adhere very strongly to the surface, so that they cannot readily be removed.

The fracture of this iron shows a light colour and slightly glossy surface, and it is no longer strongly grained. The material is still suitable for art castings, but the objects cast from it should not have thin places, as they could not be worked upon, and would require previous annealing. On account of its great density, however, this iron is well suited for castings which have to be bored or turned, and particularly for those on which polished surfaces have to be got up. The problem is to produce an iron of this kind with the peculiarity of not being inclined to chill; but this can be done by care in charging the furnaces.

No. 4, *strongly Mottled Iron.*—If the iron is strongly mottled—approaching in character to No. 5—it shows, when poured, a brighter appearance and higher metallic lustre than that last described. The fissures formed in the surface skin, are similar to those of No. 3, but the figures formed are smaller, and the changes take place more rapidly, so that a certain amount of practice is required to enable the appearances to be fixed by the eye. The formation of the gas bubbles also is more distinct, and their evolution commences at an earlier stage.

The setting of the iron takes place under conditions similar to those last described, but the surface becomes covered with numerous leaves covering larger or smaller concavities in the surface of the iron, according to whether the leaves have been formed by the combination of several bubbles, or by the adhesion of single ones. The surface is straight, and the fracture has a light fine-grained appearance. This iron cannot be used for fine art objects, but it may be employed for larger articles, which possess a certain degree of strength.

No. 5, *or Lamellar Iron.*—Of this iron we also present three sketches,

Fig. 21, Plate XXXIII., *r* representing the section of the sample when cold, *s* the appearance of the metal in the fluid state, and *t* the nature of the surface when set. When poured this iron (which is scarcely to be regarded as a white pig) shows a light brilliant colour, while the lustre which accompanies the breaking of the skin is greater than in the varieties previously noted. After pouring, a to and fro movement of the fluid metal takes place, but this only lasts a short time, being followed by the formation of stellated figures, which change rapidly and which have the shape shown in the sketches referred to above. In this metal the figures are smaller in size than those produced by the classes of iron previously spoken of, while the bubbles of gas are more frequent and of larger diameter. These bubbles unite to form the large leaves, which being hollow, cool more quickly than the mass of metal below, thus giving the surface the peculiar appearance of a red-hot mass of iron covered with dark spots, this being especially the case round the circumference, where the cooling takes place earlier. This appearance is not much liked in foundries for fine work, as it signifies an iron suitable for heavy castings only, but especially applicable to some parts of machinery. The fracture of this iron is lighter than that of the earlier numbers, and it shows fine white patches and a very dense grain.

No. 6 or "dead-white" Iron.—The conditions just described are to be found, also to a great extent, in the case of "dead-white" iron; but the formation of the figures is in this case still more rapid, and the fluidity of the iron is of less duration. The size and quantity of the gas bubbles are also considerably increased, as is also the appearance of the dark spots already referred to. The surface too when set is no longer straight, but slightly concave, while after the opening of the leaves produced by the bubbles of gas, deep holes are found, as shown by the sketches *u* and *v* on Fig. 21, Plate XXXIII., of which *u* represents the lamellar iron last spoken of, and *v* the "dead-white" iron now under notice. The difference in the two classes of iron consists, as is shown by the sketches, in the latter having not only deep but also flat holes, the existence of these proving the iron to be of a harder class than the other. The fracture of this metal shows a mixture of white and grey iron, this variety marking the transition to white iron properly so called. If the proportion of white and grey is about equal, the metal is known on the Continent as "Forellen" iron, and it has the appearance shown by sketch *w*, Fig. 22. Such iron is no longer suitable for fine castings, but if produced by a well-selected charging of the furnace, it possesses a very close structure and great strength. This iron is especially suitable for casting large rolls, which gain in strength through their cooling very slowly, and which can be subsequently turned. It is also suitable for the production of chilled castings, of which samples were exhibited at Vienna by the Innenberger Gewerkschaft of Styria.

No. 7, White Iron.—The form of this iron in section when cold, its appearance in the molten state, and the character of its surface when cold, are shown by the sketches *x*, *y*, *z*, Fig. 23, Plate XXXIII. respectively. When poured, this iron has a white colour, but this very soon changes to red, whilst the metallic lustre is very strong. The splitting or opening up of the skin does not last long, but soon makes room for the formation of large gas bubbles, which may be observed violently agitating the mass. These bubbles burst and the discharge of gas takes place with such force that fine particle of burning iron are thrown out in all directions. The surface next begins to sink, and soon after a dark skin begins to spread like a shadow over the surface of the still red hot mass, from the circumference toward the centre. Finally, this skin becomes lighter, and peels off, showing a number of the shallow cavities described above. The fracture of this iron is white, and the metal is too hard to allow of its being worked.

The characteristic appearances of the various sorts of iron above investigated, depend upon, and are intimately connected with the proportions of silicium, manganese, phosphorous, sulphur, &c. which the iron contains. If, for instance, in an otherwise normal state of the iron, the contents of sulphur in the latter is proportionately large, the so-called "Bräumen," with the leaving behind of flat holes, may be observed. The shape of the figures due to the fissures in the skin is also altered if an addition of zinc, copper, &c. is

made, and, for instance, the addition of tin causes these figures to alter their shape entirely, and gives rise to beautiful formations. It is often surprising how, for similiar reasons, the iron, which at the beginning of the observations above described, showed a distinct characteristic, alters in its appearance suddenly and unexpectedly.

The formation of distinct figures by the division of the surface skin was formerly attributed chiefly to the inclination of the iron towards crystallisation, but a closer knowledge of the composition of the metal has shown that the generation of gas dependent on this composition, and accelerated and acting through the presence of the oxygen of the air mixed with the metal by the act of pouring out, must exercise an influence upon the formation; this generation of gas being proved by the bubbles that rise and escape.

The question now is whether conclusions cannot be drawn beforehand from these observations respecting the composition of the iron, and whether a preliminary determination of the contents of sulphur, phosphorus, carbon, manganese, &c., cannot approximately be made. How important these observations would be for the iron industry, if, as has not so far been the case, they could be connected with chemical analysis, and how much more instructive would they be if microscopic investigations of the crystalline formation could be added. The latter investigations certainly deserve more thorough study than they have hitherto received, a neglect which can only be explained by the difficulty of the observations, the lens necessarily having to be placed close to the surface of the iron that is under examination, and it thus being impossible to obtain a large field of view, a few particles only being in the right focus.

Long and continued study and practical observation have made us acquainted with the treatment of iron in the foundry, and we are thus in the position to state briefly a few rules which may be useful for determining the suitable sort of iron for special classes of art castings. The following statements are therefore laid before the public with the request of an indulgent and unprejudiced judgment.

In iron bars, which show after setting, hollow internal spaces (such as must necessarily be produced in consequence of the setting growing from out to inside, if nothing is done for their prevention), there are to be found in these hollow spaces octahedral crystals more or less beautifully formed according to the degree of fluidity of the iron. Now notwithstanding the exact resemblance of the fundamental shape of the crystal, it will be found, if the various samples of iron are compared with each other in this respect, that one difference may be observed, namely the different proportions between the longitudinal and transverse axes of the crystals. The more beautifully the crystals are shaped, the more clearly is this difference of proportion observable. Very large formations of crystals are often to be seen in the more capacious cavities of large castings, but these are seldom of such pure and delicate forms as those to be found in smaller cavities. If they are completely formed they resemble small fir trees, as octahedral needles at certain distances, forming also an octahedral like space, will be found to have arranged themselves around a central axis.

By the aid of a powerful lens a similar appearance is to be found in the surfaces of fracture of iron which are more minutely examined, whilst even a smaller magnifying power shows the triangular surfaces of the crystals and their proportionately different longitudinal axes.

The same class of crystals is to be found in all kinds of iron and steel, and the similarity is often so great that the assertion might almost be made that cast iron is nothing else but a compound of bar iron crystals and graphite, and that the quality of the cast iron depends upon the proportion and character of the mixture of these components.

Such an opportunity as was presented at the Vienna Exhibition for the study and comparison of various sorts of iron is very seldom offered, and never again perhaps will such a perfect series of samples of iron and steel from all parts of the world be found again collected together as was then presented. Examining now these various sorts of iron, it will be acknowledged that to produce a certain class of castings, the pig iron forming the charges

of the cupola or melting furnace should be selected and examined with the same care as the ores for the charges of a blast furnace; but whilst in the latter case the nature and quality of the ores to be used are thoroughly investigated before being fed into the furnace, the iron for the cupola is but too generally examined only slightly and superficially, and a microscopic examination, which would offer some reliable data, is seldom resorted to. Instead of this, however, the quality of the iron is estimated from the place of its production, and if the nature of a certain brand of iron supplied by known iron works has once been ascertained, it is generally taken for granted that all further supplies from the same works will have the same qualities. Where, however, as is generally the case, the charges of the blast furnace are not always the same, the iron produced should be chemically, or at least microscopically examined before being used in the cupola for the production of castings of a given quality.

This matter, which is of such great importance, has hitherto been so little or so seldom cared for, that it is desired to direct especial attention to experimental observations in the hope that they may create some interest in the development of this important subject. The importance of this matter for the whole of the iron and steel industry will be distinctly seen in the diversity of the conditions of the various sorts of Bessemer pig after the changes in the different stages of the Bessemer process, and a comparison of the processes brought, at the Vienna Exhibition, before the public was highly interesting.

Whilst for instance, the grey Swedish Bessemer pig changes under the slightest treatment quickly at first into spiegeleisen, the Bessemer metal exhibited in the various stages of treatment by Ockhowo, Government Ekaterinoshan (Russia), shows, even in the higher stages of the Bessemer process, still some graphite. With respect to the foundry, the iron containing carbon in a fixed state cannot be cast well (the appearance of the malleable cast iron should be considered), nor does it allow of any working treatment, and is thus not so good as that (according to the opinion expressed above) consisting of a mixture of wrought-iron crystals and graphite; it is therefore of great importance for the foundry that a pig iron should be used which has not the qualities of the Swedish iron, but that of the iron exhibited by Ockhowo.

It has to be considered that the iron, having become fluid in the higher temperatures of the ordinary cupola, has to pass in its descent through the current of air still saturated with oxygen, that it is subjected to an alteration similar to the fining process, and that it will become white and hard if the formation of graphite has not been re-constituted by the abundance of carbon. In connexion with this matter we may mention the cupola furnace invented by Herr Krigar, of Hanover, this furnace being constructed so that the molten iron is withdrawn from contact with the coke and blast, the hearth for receiving the iron being to one side of the furnace and not directly below the crucible as usual. When this furnace has been correctly put up, its use has always been attended with an economy of coke; but this is not its only advantage, a leading feature being the decrease of the danger of producing white and hard iron. Hence in a furnace on Krigar's system, a larger percentage of coke iron may be added to charcoal iron without producing a white metal, than is possible under ordinary circumstances. In fact in Krigar's furnace a suitable metal for art castings may be obtained by the use of coke iron, although, of course, charcoal iron is always to be preferred.

In support of the opinion that no iron having an inclination to get white should be applied for art castings, we may refer to the fine iron castings exhibited by Rastorgonieff, of the Usines de Kischtim, near Perm, in the Ural (Russia), which have been produced by previously submitting the iron used for them to a trial in open sand moulds, when it was first determined that the iron would not get white, but would remain grey; if this result was not attained the iron was not used.

It is further certainly erroneous to suppose that a large per-centage of phosphorus, which tends to make iron become white, is especially advantageous for art castings, and this opinion is only correct in so far that the

normal working of a blast furnace using limonite ores, produces an iron free from "kish" or iron froth, and which is of a very fluid nature, penetrating sharply into every form, although it is hard and possesses the necessary strength.

This quality and that of other sorts of iron corresponds exactly with their point of fusion, and many occurrences, often of considerable disadvantage, depend upon it; amongst the most disadvantageous is, however, that of the so-called burning (Anbrandes), which shows itself by rough or file-like surfaces, which take away from the castings all fineness and exactness, and make them look imperfect and almost useless. A closer examination shows that these rough surfaces have been produced by the accumulation of small projections, which partly cover the casting, and with a certain thickness. This appearance is entirely independent of the moulder's work, and even if the latter has been executed as carefully as possible, and the best casting might have been expected, the surfaces are, nevertheless, covered with projections and grains. The reason for this can, therefore, only be in the quality of the iron. It has been endeavoured to ascertain the reason for this chemically, and it is said to have been discovered that the projections forming the rough surfaces were special compounds of iron and other bodies. This, as will be seen hereafter, is correct; but it alone does not explain the mechanical processes that take place in connexion with it. Our own opinion on this matter is as follows:—

The iron in a fluid state will be no homogeneous body, but a composition of various compounds between iron and phosphorus, iron and sulphur, iron and manganese, iron and carbon, iron and silicium, &c. Each compound has, however, a certain point of fusion, the one lower than the other. Now if mixtures, which differ much with respect to their point of fusion, form the iron, one portion of the latter will set whilst the other portion remains in a fluid state, this latter part being forced by the contraction of the former portion through the pores, which are still open during the red-hot state of this portion of the iron, and in this manner the so-called burning or "Anbrand" is produced.

After having recognised this cause, it became possible to produce another sort of iron by other charges. We have met with examples of iron upon which are to be seen small balls of the size of peas, in consequence of the great difference between the points of fusion of different parts of the metal. Many other similar occurrences might be explained in the same manner.*

A consideration of the facts above stated showing that it is desirable to possess some simple mode of determining the relative points of fusion of different classes of iron, Mr. Schott, the director of the celebrated Ilsenberg foundry, some years ago devised the following method, which, although of course only capable of affording approximate results, he has found answer well in practice.

An iron vessel, weighing about 25 kilogrammes, is filled to a certain height with water, so that it contains exactly 48 kilogrammes. When fluid iron is poured in, the temperature of the water will increase in proportion to the temperature and the volume of the iron; and this increase of temperature is then applied for determining the relative points of fusion of the various sorts of iron in the following manner:—

After having measured the temperature of the water, a portion of fluid iron as taken from the blast furnace or the cupola is poured into the water as quickly as possible. The water is then stirred, when the temperature is again observed. The water is now carefully tapped off, and the iron is taken out, dried, and weighed. The weight is thus obtained, which at a certain temperature produced the observed increase of the temperature of the

* Professor Gruner, in his article on steel, "Annales des Mines," xii., vi., serie, 4 liv., 1867, says, "From these results (various analyses of pig iron) it will be seen that in the "varieties of grey pig iron rich in manganese the silicium is mostly combined with the "manganese." Further, "The analyses show that the varieties of grey pig iron must "often contain more than 10 per cent. of foreign bodies, and that their number must be "very considerable, &c.; even the white sorts of iron produced from spiegeleisen, which "are acknowledged as being very pure, have, in reality, a very complicated composition.

48 kilogrammes of water. Various degrees of heat will produce various differences of temperature, but as it is not always possible to use equally large quantities of iron, whilst the results are in proportion to these quantities, the following formula has been found to give the relative weight for a certain degree of heat of the iron :—

Let the quantities of water used in two experiments, carried out in the way above described, be represented by W and w respectively, and let also I and i be the corresponding quantities of iron used; T and t the differences of temperature produced in the water, and H and h the quantities of heat imparted to the latter per unit of weight of the iron. Then evidently

$$H : : h = \frac{W\,T}{I} : : \frac{w\,t}{i}.$$

But the quantity of water is constant, or W = w, therefore

$$H : h = \frac{T}{I} : \frac{t}{i}, \text{ or } H : h = T\,i : t\,I,$$

whence it follows that, if we give the result, H, obtained, in any one instance a certain standard value, the corresponding value of h, derived from another experiment, will be given by the simple formula :—

$$h = \frac{H \times t \times I}{T \times i}.$$

It is evident that H and h, instead of being expressed in pound-degrees of heat given out per unit of weight of iron, may, for practical purposes, be more conveniently expressed by the degrees of temperature representing the respective melting points, and this is really what is done at Ilsenberg, the temperature of 1200 Reaumur (2732 deg. Fahr.) being taken as the standard value, while differences of temperature of 370 deg. Reaumur (864½ deg. Fahr.) have been found. It is to be noted that this mode of estimating relative melting points takes no account of the latent heat set free during the solidifying of the iron, but regards all the heat imparted to the water as if it was merely due to the sensible heat abstracted from the iron during its cooling down from the melting point. No doubt this fact introduces an error, while other errors may be induced by the want of care in pouring the iron into the water just before setting; but these errors do not affect the value of the system as a rough-and-ready practical method of ascertaining the relative fusion points of different samples, and, as we have said, it has been found effective and useful at the Ilsenberg foundry.

Although less important for art castings, which are generally of no great weight and dimensions, we should nevertheless not omit to mention a law of nature, which exercises an important influence on the density of the iron, and respecting which a few words have already been said in the article published in *Engineering*, in 1867, on the same subject. We refer to the condition of the fluid iron during the setting, and to the circumstance that, if the latter is not allowed to proceed uninterruptedly, and if the full influence exercised by the power of crystallisation of uniting the atoms according to fixed laws, is prevented by shaking or stirring, a denser union of the atoms may be produced. Attention may be called here to the process of melting and setting of several substances, especially of stearine, in which so many analogous conditions are to be observed, that it might well be selected for explaining all these procedures. We may accept as a general law of the molecular aggregation of all crystalline solid bodies, that if particles of the latter pass from the fluid into the solid state, the crystals of the substances arrange themselves under the influence of the cooling and are grouped with their chief axes in certain directions. The hardening of steel has been considered as a mechanical interruption of the uniform crystallisation (Cizancourt, Comptes Rendûs, vol. 57), in consequence of which a denser arrangement of the particles takes place; an interruption during the setting of the fluid pig iron by means of stirring, &c., will and does exercise a similar influence. That the existence of such an influence was practically acknowledged long ago, even if theoretically unknown, is proved by the manipula-

tions adopted for castings of railway-carriage wheels, projectiles, &c., for which great strength is required; these manipulations, including a stirring of the fluid iron up to the moment of casting, with a bent wrought-iron bar. Even the now generally employed so-called "pumping," that is to say, the pushing up and down of an iron rod into the mouth of the finished casting, is certainly not merely the result of the requirement that the mouth should be kept open for an additional supply of fluid iron.*

The difference between the temperature of the fluid iron and that of the sand mould being so considerable in small art castings, a quick setting takes place, which, as mentioned above, may be considered as a mechanical interruption, not allowing of a regular crystallisation; whence for the castings of this kind no special treatment of the fluid iron is required. However, for art castings of larger dimensions and weight, the manipulation mentioned above is to be recommended.

Preparation of the moulds.—Having now dealt with the most important factors in the production of iron art castings, namely, sand and iron, we may speak about the third factor, namely, the preparation of the moulds, and we shall again begin by giving a brief report of the moulding operations employed during the sixteenth century, at which time, as stated in our first article, the art of casting had reached a high perfection. According to descriptions taken from masters themselves of that period (see Goethe, appendix to the biography of Benvenuto Cellini), two modes of proceeding were adopted for the moulding of art castings—the pattern, in one of these methods, being lost by using it as a core. The pattern was made of clay of the same size as the casting had to be, it was then allowed to shrink, and finally burnt or roasted, when it was covered carefully with wax, thus again regaining its original form and size. Over the pattern, prepared in this manner, a fireproof mould was made, the wax was melted out, and the space thus made free between mould and pattern was filled with the fluid iron.

According to the second mode of proceeding the clay pattern received a light coating of turpentine and wax, and was covered afterwards with thin leaves of tin-foil. This was done in order to prevent the moisture from damaging the pattern when a mould of plaster-of-paris was made over it, the latter being made in such a manner that it could be taken into pieces, and that wax could be conveniently pressed into it of the same thickness as the casting had to be. The inside frame or skeleton necessary for the casting of the object was then made of iron rods and wires, and was covered with a fireproof substance until this core touched the surface of the impressed wax; the inner mould and core having thus always to be tried against each other. This surface of wax was then taken from the mould, and the latter and the core were connected with each other, when the free space between the two was again filled with molten wax. The mould of plaster of Paris was now taken off again and the new pattern was carefully worked over, wax rods being put from part to part according to the channels through which the fluid iron had afterwards to run, because everything that had to be hollow in the mould, and that had to serve as channels for the passage of the fluid iron, had to be worked out on the pattern in wax. Over this well-prepared wax pattern a fireproof mould was made, this mould being provided at the bottom with a few openings, through which the wax might run off after it had been melted by a slow fire, over which the mould was placed. When the whole of the wax had run out of the mould the latter was once more carefully dried, and was then ready for the casting of the metal.

In order to obtain a comparison with the mode now usually adopted for preparing the moulds for art castings, we may refer here to a well-known object of high artistic value, namely, the "Minerva Vase" of the Hildesheim silver font. This, it is true, is a work of chased silver, and is not cast, but bearing in mind the preceding description, it will be easy to imagine the manner in which the problem of producing this work of art by casting would

* For further proofs of the opinion expressed above, we refer to Hausmann's "Uber die "durch Molecular bewegung in starren, Leblosen Körpern bewirkten Formveränderun-"gen," Göttingen, 1856, to Tunner's reports in the journal of the Imperial School of Mines at Leoben, and to Dürre's excellent work "On the Constitution of Pig Iron."

formerly have been solved. It would have been modelled in clay, would have been covered with a layer of wax, and after having been carefully embossed, the wax would have been melted out, the mould have been dried, and the casting executed. What a tedious and difficult work this must have been, and what clever hands must have been required to undertake such a task in order to secure success. However, the present mode of moulding is more simple, and offers the same degree of safety, while it has been brought to a perfection the best proofs of which were the various objects exhibited by many foundries at Vienna.

These proofs demonstrated in various ways, and by various specialities, the development which "art casting" has attained; and while, for instance, the Ilsenburg foundry astonishes us with the most important ancient works of art, reproduced by iron castings in a magnificent manner, we must also admire and acknowledge the highly artistic productions of Durenne, who sent from Paris large groups cast in iron. Other foundries also showed important works, and we may call special attention to the exhibits of Val d'Osne, Lauchhammer, Wasseralfingen, Carlshütte-on-the-Weser, Mr. Wagner, of Vienna, and many others.

We shall now attempt to show the mode at present usually adopted for preparing the moulds of fine and artistic castings in iron, by explaining the manipulations which had to be carried out in order to reproduce a fine and exact copy in iron of the "Minerva Vase" mentioned above. The patterns of the justly admired and appreciated vase—with the figure of Minerva in a sitting position, carrying in the right-hand a rudder, and on the left arm a projecting shield—are divided into several parts, namely, the vase in two, one of which is formed by the bent margin, the figure in two, the handles in two, and the foot in two.

At first the vase is placed up to the limit of the upper part in a gauge-board, and is filled with firmly stamped sand up to the top, when the surface is made smooth and is covered with coarse pounded charcoal in order to prevent the adherence of the following sand. The bottom part of the moulding box is then placed over the vase, the projecting margin is moulded, the box with the gauge board is turned over, the latter is removed, the other part of the box is placed upon it in order to mould the back of the vase and the wooden pattern forming the mouth for the inlet of the fluid metal, and which had been previously moulded in, is then taken out. After these manipulations the parts of the moulding box are separated again; the pattern is taken out in parts, the mould is moistened a little with a brush, and dusted with fine sand and pounded charcoal, when the pattern is placed once more into the mould in order to correct any small defects; after all these manipulations have been carried out, the moulding box is put and fastened together. The further manner of proceeding, until the casting takes place, is too well known, and does not require any description. The figure at the bottom of the vase cannot, however, be produced in such a simple manner. The shape of the dress, of the head, of the arms, of the shield, of the helmet, &c., will not allow of a simple moulding as a whole, but it has to be accomplished in pieces by means of false cores, which require a more solid consistency than the ordinary moulding sand. For this purpose the fine moulding sand, which is in direct contact with the pattern, is covered with a more fat and less porous sort of sand, consisting of coarse grained quartz and a sufficient quantity of clay, when the false cores are prepared in the same manner as for castings with plaster of Paris. The outside of the false cores is dusted with coarsely powdered charcoal, the part of the moulding box, after being entirely filled with sand, is turned over, the other part is placed upon it in order to mould the back, the inlet for the fluid metal being moulded in. The parts of the moulding box are now separated again, the false cores are taken separately from the pattern, and are put in the proper places, where they are fastened by means of pins. After any defects have been repaired in the usual manner, the parts of the moulding box are put and fastened together. In a similar manner the remaining parts, handles, and foot are moulded.

If the ancient masters in the art of casting could have known the correct mode of preparing the sand, what works of art would they not have produced, and in what numbers, as the pattern is no longer destroyed by the preparation of the mould, but may be used for repeated castings.

Preservation of Art Castings.—If the advice given above is followed, and if the production of the iron, the preparation of the sand, and the formation of the moulds are conducted in accordance with the hints stated, a successful, exact, and smooth casting may safely be expected; while the exhibits at Vienna of the Ilsenburg Foundry, the Carlshütte, near Alfeld-Hannover, the Königshütte in the Hartz, the Lauchhammer Iron Works in Saxony, the Mädgesprung Iron Works in the Hartz, the Schebanoff Foundry of Moscow, &c., showed that such castings may be of a perfection equal in every respect to galvano-plastic precipitates. Naturally the desire must next be entertained to preserve the fine surfaces of such castings, so that the latter may retain their appearance, just as if they were of the higher metals, such as gold, silver, platina, &c. Unfortunately, however, iron is one of the elements which have a great affinity for oxygen, and which enter into very intimate relations with the latter. How much trouble, care, and inconvenience would be saved to the ironfounder, if this were not the case; whilst works of gold and silver retain their original form and shape for many centuries, during which time they may have been hidden under the cover of the earth, the unrelenting rust in a very short period so changes works of iron that their original form is scarcely recognisable; and up to the present time no safe and lasting protection has been discovered against this influence of hydrogen and oxygen. Hydrated peroxide of iron and sesquioxide of iron, which are to be highly valued as bases for colours, remind the ironfounder—and especially he who has to produce fine art castings—of a thousand fatalities; and we can well appreciate the vexation and regrets of a man having a love of his work, when he perceives the first traces of rust on a casting prepared carefully according to all the rules of his art, and protected by means which have ever been recommended on all sides. We intend, therefore, next to speak of the means which should be adopted to secure for art castings in iron the longest possible protection, and amongst these a coating produced by electrotyping with metals having a less affinity for oxygen than iron, takes the first place.

As the greatest calamity has generally some fortunate circumstances connected with it, so the great affinity between iron and oxygen favours the procedure of providing the former with a cover of a protecting metal. It is well known that copper is forced by iron to give up its connexion with oxygen, if iron be added to a solution of a salt of copper, the oxygen then preferring to join the iron, which takes the place of the copper, whilst the latter goes into the place of the particles of iron which are dissolved by the disengaged acids, and forms thus a fine reddish coating that would be very welcome if it would adhere. This, however, is unfortunately not the case. The relative effect of this chemical process is so great that the particles of copper cover the iron as crystals, and on account of their size can form only a loose connexion. In order to secure this precipitate, it is best to prepare by means of cyanide of potash, a cyanuret of copper, and to regulate the force of the galvanic current which has to effect the precipitation, the result being that the precipitate becomes finer and more fixed as the force of the current is diminished. Another way of retarding the effect of decomposition is by an addition of some acid to a solution of a neutral salt of copper, and if the addition is a correct one, the precipitate of copper then obtained will be found to be firmly fixed, so that it can be removed by file and chisel only. If the surface of the iron, which has to be covered with this protecting coating, is entirely clean, so that the copper precipitate is not broken at any place, the aim is then perfectly reached; unfortunately, however, the preparation of an absolutely clean surface is a difficult matter in the case of art castings; but still it is decidedly necessary if a perfect protection against rust has to be obtained. The least break—an opening which cannot be perceived with the unprotected eye—is sufficient, with the addition of a little moisture, to produce a galvanic effect between the two metals, and as soon

as a current has been once started between them, the effect is shown, to the detriment of the iron, by the presence of a small point of hydrated peroxide of iron, this small point increasing and extending under the coating of copper, and giving to the casting, produced in the highest perfection, the appearance of an old and much-used object.

By the help of the electrotyping process iron may also be covered with other metals, but no better results can be obtained than with copper, as the circumstances explained above are the same, and have the same effect. A special perfection of copper coating, &c., was shown by the castings exhibited at Vienna by the Lauchhammer Iron Works, the Magdesprung Foundry, and the Ilsenburg Foundry for art castings. The latter is able to give to the largest ornamental castings the appearance of bronze castings, as is proved by examples at many of the public and municipal buildings of Berlin. Nearly all the castings of the Berlin new Town Hall, new Exchange, &c., which appear to be of bronze, and which are always taken as such, have been cast in iron, and afterwards bronzed by an electrotyping process at Ilsenburg. Even an influential Berlin paper* described the *bronze* doors, balustrades, and lamp-posts of the Town Hall.

A further and still greater improvement may certainly be expected, if the great difficulties and expenses connected with this work are not feared, and if the discoveries and experiences lately made are taken into consideration.

Another process, carried out at Paris to a large extent by Oudry, who was animated to special exertions by considerable assistance from the French Government and the city of Paris, consists in carefully giving the iron casting a coating of red lead with oil, next making its surface conductive by means of graphite, and placing it afterwards in a solution of sulphate of copper mixed with a zinc solution, made ready for the ordinary process of the galvanic copper precipitate. The copper skin, which increases in thickness in proportion to the time allowed for the process, offers, if protected against outside damages, a lasting and safe protection against rusting, although this process is to be recommended only in cases where the casting is secured against any rough usage. Besides, the sharpness and the clear appearance of the casting is much altered by the thick but necessary coating with red lead colour, and the casting looks as if produced by unskilful hands. The metallic coatings applied by the electrotyping process directly on the cleaned surface of the iron, as described above, are certainly to be preferred under all circumstances in cases where no protection against mechanical damage exists. This process offers besides the great advantage that the colour may be regulated at will, and that according to the force of the electric current, all tints of bronze and of other copper alloys may be produced with the same solution, if the latter contains all the necessary metals which have to be added to the copper for the various bronzes and alloys. The zinc will predominate with the strongest current, and the copper with the weakest current.

The best coating as a protection against the rust, is, for suitable castings, that given by an enamelling process, and we notice with much interest the great progress that has been made in this process, so that now large vessels for the manufacture of paper, for instance, baths, &c., are protected in this manner. Unfortunately, however, the great expense connected with this process prevents its general application, which can, and must besides, be limited to the class of castings just mentioned, as in the case of art products it is certainly desirable to preserve for the iron its metallic appearance. Any surface imitation of another material is not justifiable, as it does not correspond with the dimensions which ought to be analogous with the strength and the character of the metal. The style of iron building followed at the present time is therefore to be well recommended, as it frees the architect from the old rules and laws which had been laid down by the ancient masters for construction in stone and timber. The eye certainly prefers for iron the lighter constructions, in the same manner as it likes the

* *Voss Zeitung* of the 27th of February 1870.

ancient forms for stone and timber; and if we admire the ancient rules for the different orders of columns, we do so for stone only, whilst the knowledge of the greater strength of iron gives us the right to expect some lighter designs.

Returning again to the means of protecting iron castings against rust, we should first mention the progress which has been made in giving coatings by the electrotype process during the last few years. Scarcely any metal has been left untried for the production of a coating, and a coating of nickel has, especially lately, been much adopted, on account of the slight affinity of this metal for oxygen. The nickel coating has a white-grey agreeable colour, and is now often applied as a protection even to ordinary castings, because it does not oxidise when exposed to the air, or even to moisture.

The tin and zinc coatings produced by deposition from chloric solutions also offer to the iron a protection against rust, and have already been largely applied. The zinc coatings especially are much used, being really lasting means of protection on account of the white oxide of zinc, which is gradually produced in contact with the air, offering the best protection against any further oxidation, as it resists any further influence of the weather.

If it is desired to give iron castings a more valuable and more beautiful appearance, a coating of gold or silver must be adopted. Either of these metals can be firmly attached directly to the surface of the iron by deposition from cyanide solutions; they will, however, never have the same appearance as if precipitated on copper or brass, but will always be of a slightly dirty tint. It is, therefore, desirable to cover the iron castings at first with a reddish or yellowish galvanic bronze coating, according as a lighter or darker tint is required. If such a coating is produced cleanly, the best results may be expected.

The cleaning of the surface of the iron castings is best effected by dipping the latter, for a short time, into a bath of diluted sulphuric acid. Immediately afterwards the casting should be placed for a longer time in a bath of lime water in order to insure that all free acid shall be removed. When that is the case, the casting should be carefully brushed with iron or brass wire brushes. A thorough, and especially a quick treatment of the casting, is necessary to obtain those clean surfaces upon which depends, as stated above, the success of the galvanic coating. The castings, thus covered with bronze, gold, silver, nickel, copper, &c., are submitted to the same manipulation with brass wire brushes, according as bright or dull surfaces are required. Entirely smooth surfaces, which allow of being polished, are taken for this purpose after coming from the bath of lime water to the polishing lathe. The polishing of gilded and silvered castings is effected by means of the ordinary polishing stones, but the same manipulation has to be repeated with the burnisher before the galvanising can be proceeded with. Oil gilding made with leaf gold, on a ground of oil varnish and chrome yellow, is sufficient for many purposes; and that it is lasting, if carried out with the necessary care, is proved by the ancient gilding of pulpits, church fittings, railings, &c., prepared in this manner. In order to carry out such gilding properly, and to make it lasting, it is important that the under-ground should be correctly prepared, and this depends principally upon the quality of the varnish and of the drying of the latter. If oil-varnish colour is kept for any length of time in an open vessel, a thick and strong skin is formed, under which the remainder of the contents will keep in an unaltered and fluid state for some time. The problem is to give to the varnish-colour used as the groundwork for the gilding the time and opportunity to form such a skin, and this can be done only if the coating is dried to such an extent in the atmospheric air, and not by heat artificially produced, that the coating possesses just the necessary stickiness for the fixing of the leaf gold. If this drying be effected by artificial heat, an evaporation of the oily matter takes place, and the non-evaporative substances of the colour remain, which substances do not possess the protecting power of the varnish skin against the rust. Gilding carried out in this latter manner is not durable, whilst the former process secures for it its original and unaltered beauty. In general,

the same rule has to be observed, not only for the groundwork of gilding, but for any varnish coating.

The artificial bronze coating with bronze powders placed on grounds prepared in this manner with varnish or drop colours, always present in time a disagreeable appearance, and lose their metallic lustre. In order to prevent this, they require necessarily an oil-varnish coating, which does not destroy the metallic appearance, but which produces a glassy surface, and which is consequently not yet much applied to iron castings. Several processes for the production of an artificial bronzing, and imitation of the antique green patina appearance, have been introduced, and most successfully, by French painters, who produce almost incredibly close imitations, as was proved by the beautiful exhibits at Vienna, in the small French pavilion of the works for "Peinture Decorative sur Feuilles d'Etain," 12, Rue de Rocy, of Paris.

A new varnish colour, introduced under the name of "diamond colour," has been found to offer great protection for the iron against rust; this colour has been used much, and has in all cases given good results. But this coating is not only of great advantage on account of its lasting qualities, but also on account of its peculiar greyish-blue tint, which preserves for the iron its proper character, and makes iron look like iron, which must always be a satisfaction.

A specially agreeable tint can be given to the iron, and still more satisfactorily to the clean surfaces of steel, and the denser structure of wrought iron, by annealing colours; this process has been much developed by Professor Reuleaux, director of the Polytechnic School at Berlin, as was proved by the exhibits of this school in the pavilion for German educational purposes. The process is a very simple one, and depends upon the various tints, such as yellow, bronze-like, blue, dark blue, and even black, which may be given to the steel or iron by different degrees of heating. The dark tint shown in the German department of the Exhibition, as mentioned above and which had been prepared according to the instructions of Professor Reuleaux, is especially of remarkable beauty. For the production of this latter tint, it is necessary to raise the object to a red-brown heat, so that paper placed upon it turns yellow; linseed oil has then to be poured over the object, which is next rubbed clean as quickly as possible.

We should finally mention another excellent way of protecting iron against rust, and this is the little-known and so-called "Absanden," or sand-covering. For this purpose, the iron casting is at first painted with a red-lead colour, mixed with oil varnish, and after this coat has dried perfectly, a colour of sulphuret of zinc, which is to be obtained in the market in such a fine condition that it gives, mixed with oil-varnish, a good stone colour for immediate use, is laid on, when immediately afterwards sand of any colour is dusted fully over it. When the sand has become firmly united with the colour, the latter is laid on again, to be followed once more by the dusting with sand. Such a covering will resist the influence of the weather for almost any time, and it may also be used with perfect success as a protection for timber.

Iron Castings for Building and Ornamental Purposes.

Our above remarks referring especially to art castings in iron, have contained, however, many references to iron castings in general, and we now, in reporting briefly on castings for building and ornamental purposes, must refer to the practical hints already given with regard to the production of iron suitable for fine castings and on the preparation of the moulding sand necessary for such work.

Amongst ornamental castings we may include trellis or perforated work, fillings for doors, screens for air and water-heating apparatus, tables and stands for flowers, fountains, vessels, and monuments; while the castings for building purposes, of which we propose now to speak, include rail posts, banisters, chimney pieces and stoves, iron furniture, monuments for tombs, wells, stairs (circular and straight), verandahs, balconies, columns, brackets, doors and gates, railings, girders, windows, stable fittings, pavilions, greenhouses, &c.

In dealing with this section of our subject we propose first to speak about the preparation of the moulding sand necessary for the casting of the objects just enumerated, and referring to what has been said about this when dealing with art castings, we may state at once that the success of the work depends in these cases, also, chiefly on the penetrability of the sand. The latter must besides, be of a fine grain in order to allow the most distinct impressions to be obtained, whilst another great feature which has to be taken into consideration in the preparation of this sand is the large quantity of fluid iron used for producing castings for ornamental and building purposes. The sand must be therefore of sufficient density without losing any of its penetrability.

In our former remarks we have described the mode of preparing the sand for various purposes adopted at the Ilsenburg Foundry, and with reference to these rules, which may, besides be considered as a suitable standard for any foundry, we shall now state our views regarding the sand to be employed for castings for ornamental and building purposes:—

1. For fine ornaments with high projecting details, four parts of the red stony sand, previously described, should be taken, and after being moistened and well kneaded together, should be mixed with five parts of loamy sand, this latter consisting of roasted or dry, and raw sand-loam in equal proportions. This mixture of sand after being sifted is to be placed directly upon the pattern, which has previously been covered with coal dust in order to facilitate its removal, whilst highly penetrable sand is to be used for backing up.

2. For larger ornaments the same sand as described above may be used, but to the four parts of red stony sand three, instead of five, parts of loamy sand should be added, this alteration being made in order to facilitate the escape of the larger quantity of gases produced in these castings, whilst care should be taken that the sand does not lose any of its binding power.

3. For objects which require a particularly smooth surface, as plates and crosses for graves, &c., one part of loamy sand is to be mixed with two parts of stony sand. For these castings it is especially necessary that any disturbance of the iron—such as is caused by the generation of the gases as soon as the latter meet with the slightest resistance—should be prevented. This purpose is at first obtained by the great penetrability of the sand prepared in the manner just mentioned. Besides, however, special air holes are necessary above and below the mould, and these may be produced either by piercing through the sand long pieces of smooth wire one-sixteenth or one-eighth of an inch in diameter, or by putting these wires, for which also cords may be substituted, into the sand during the moulding, and by carefully drawing them out afterwards, the moulding boxes being provided with the necessary openings at the sides to enable this to be done. It should be remembered that the sand placed on the pattern will get denser through the necessary manipulations with the moulder's tools, and this is even facilitated and necessitated by the proportionate mixture of two parts of stony sand with one part of loamy sand.

From the information given above, it will be seen that the sand consisting of two parts of stony sand and one part of loamy sand should be used for those ornamental castings which bear a close relation to art castings, that for the second class of ornamental castings sand consisting of four parts of stony sand and three parts of loamy sand should be adopted, whilst castings for building purposes should be moulded in sand, which is composed of four parts of stony sand and five parts of loamy sand.

In order to increase the strength of the sand without diminishing its penetrability, nails or pieces of wire should be placed in it, the former being more suited for surfaces, and the latter for grooves, edges, and corners. Nails, however, are often applied in a useless and unnecessary manner, and are frequently employed in cases where a drawing off of the surface of sand through the heat of the liquid iron has not to be apprehended; such an occurrence takes place only where iron is used in large quantities, and where the pouring in occupies a considerable time. It should be considered moreover, that the nails expand by the heat, and much damage is often done

without having its cause explained, by overlooking this fact. Thus not only is the mould damaged, but it is also very annoying to find on the casting an impression of every nail in the mould.

The use of nails is, however, especially necessary at the mouth of the mould in order to prevent a washing away of the sand during the prolonged pouring in of the metal such as occurs with castings for ornamental and building purposes; whilst nails or pieces of wire should be applied to moulds with deep recesses in the following manner:—After the pattern has been placed on the loam bottom and the box has been put over it, the sand No. 2 is sifted in up the height to the pattern, when nails with their heads towards the bottom are put into the sand forming the recesses, after which manipulation sand is thrown, *not rammed*, into the moulding-box until the latter is filled, and only then is the whole mass of sand rammed down, whilst the putting of wires or cords through the lower sand should not be omitted. Very deep recesses may thus be produced more successfully than by using for such recesses sand of a higher binding power, and therefore less permeable character, in which latter case the fluid iron gets disturbed, making smooth surfaces—which in many cases, as for instance, in dies, &c., are of the greatest importance—an utter impossibility.

We may mention here a circumstance which is often neglected, and the consequences of which are generally attributed to other causes, often even to the application of nails and wires. We allude to the influence of the tapered shape of the mouth-pieces in the moulds, and which may be compared with a nail, the larger part at the top of the mouth corresponding with the head of the nail, and preventing thus, as the nail would do, a drawing into the sand during the setting of the metal.

In consequence of this shape of the mouth and also of the edges formed at the top during the pouring of the metal, the runner cannot follow the setting and contraction of the metal in the mould, whence the latter, still red hot and very brittle at that temperature, is torn from the runner, causing often such damage that the casting cannot be used. Care should therefore be taken that if during the pouring out of the metal, edges are formed, and if they have even the thickness of note paper only (for in that case they are especially objectionable, on account of the early setting of this insignificant thickness) the runners should be freed in due time from the sand, but of course only when the liquid metal cannot any longer do damage to the mould.

Further, care has to be taken respecting the escaping gas; it should meet, when passing out of the mould, with a temperature sufficiently high to at once ignite it, otherwise it forms a combination with the oxygen of the air, and containing mostly hydrogen gas, it forms oxyhydrogen gas, which ignites and explodes suddenly, whence great damage is often done to the mould. For castings for ornamental and building purposes, special care should therefore be taken that the escaping gas comes at once in contact with burning bodies, as for instance, burning straw, wood, shavings, &c.

In order to mould patterns with ornamental work on both sides, and which require the exact moulding of one-half of the pattern if the latter is not divided into halves—which should be prevented as much as possible—so called "templet moulds" (Lehrböden) may be used, especially in cases where many castings have to be made of the same pattern. For this purpose an exact "bed" for one side of the pattern is made of sand, plaster of Paris, or earthy gypsum, into which the pattern is placed; the upper side of the latter is then moulded, and after the flask with the pattern has been lifted up, the second part of the pattern, which was previously supported by the bed, is moulded in the second flask. This arrangement, which is often employed, is mentioned here in order to state that the "templet moulds" may suitably be made of sand, in those cases where the latter is of a less shrinking but well-binding quality, the so-called "dry sand" consisting of a conglomerate of coarse grains of quartz and fat loam. This sand allows "templet moulds" to be made, which may be used several times, but not so safely as those made of plaster of Paris, which, of course, are much more expensive. If coarse pebbles and fat loam sand are at hand, the suitable sand may be produced artificially by bringing a mixture of equal parts of the above

materials under the stones of the loam mill; if only a small number of ornaments have to be cast, this sand may be used with advantage, whilst a mixture of sand and plaster of Paris, which is less expensive than pure plaster of Paris alone, and which offers nearly the same security, should be used in cases where the number of castings is large.

Another method offering great advantages for the moulding of a large number of one and the same article is the substitution of planed plates or boards for the "templet moulds," one half of the pattern (if the two halves of the latter are exactly the same in every respect) being fixed on the plate. This one half of the pattern may then be used for moulding the upper and the lower flask, whence a great saving in the pattern is effected, and the work of the moulder is greatly facilitated. Of course the two flasks of the moulding-box must be made to correspond exactly with each other by means of iron pegs. This method of plate-moulding may, however, be still further improved by providing the planed plate with an opening corresponding exactly in size to the outline of the pattern, so that the latter may be drawn out of the sand by any contrivance, as, for instance, by screws, racks or levers, &c. This is the idea upon which the construction of moulding machines, now largely used for the moulding of wheels, &c., has been based.

Wrought or Malleable Iron.

According to the words of a great philosopher, nothing new is to be found under the sun, and adopting this view, we may say that almost all metallurgical inventions accepted as novelties by our generation, can be traced back to times far beyond the reach of metallurgical literature.

We have already shown that the art of casting was known to our ancestors long before iron was a commercial product—we may almost say long before anybody knew of its existence. The subject of the present division again leads us to the same reflections, for what modern metallurgists are aiming at as the desideratum of iron industry, viz., the manufacture of malleable iron direct from the ore, was precisely the system used in the infancy of this industrial branch. Squabblers may object that at the present time we have to deal with quantities of materials such as the blacksmiths of ancient times never dared to dream of. True; but this, too, entirely coincides with the views we have already put forth, namely, that the progress and development of metallurgical industry must be sought for, far more in the increase of the masses dealt with, than in the invention and introduction of really new principles of manufacture. Malleable iron manufacture, direct from the ore was known on the continent long before the Christian era, and the process itself, as well as the conversion of the raw metal into different articles, must have gained some perfection at the time. At least, we find in the reports of Cæsar, that the "magnæ ferrariæ" of Gallia enabled the Veneti, the inhabitants of the ocean shores, to forge chains, by means of which they secured their anchors, and thus saved their own ships, while the vessels of the Romans, only moored with hemp cables, were torn away from their moorings, and lost. Another statement shows that the inhabitants of Avaricum were accustomed to gain their iron ores from underground mines. Innumerable are the slag mounds dispersed on the continent as remembrances of the diffusion of this industry.

At first, when road communications were scarce and the transport to any great distance a matter of nearly insurmountable difficulty, the iron manufacture was necessarily confined to those places where ores of the richest quality, and a sufficient supply of fuel (charcoal), were to be met with close together; and as these conditions generally were found to take place where deposits of the purest ores were encountered, it followed, as a matter of course, that the forges of that time yielded the very best products for commerce.

Another consequence was the multiplicity of the forges, which were erected wherever the above-named conditions were traced. The very diminutive production of these forges everywhere opened a market for their articles, and thus secured their existence. At the beginning of the present century this organisation underwent a rapid and thorough change, inasmuch as the communications were facilitated by the amelioration of the roads and by the

introduction of canals, railways, &c. The possibility of obtaining ores or fuel from more remote districts, and the facility of sending the manufactured articles to any distance for sale, at once revolutionised the whole system of the trade, and a general reduction of prices was the immediate consequence, so that those forges which had not the same facilities for business as others situated on or near the large arteries of communication were obliged to stop their work.

A striking example of the influence of communications upon metallurgical industry is given by the exhibits shown at Vienna by the Styrian and Carinthian iron manufacturers. We cited this instructive exhibition in a former division of this section, and we here again find it to be of value in aiding the thorough understanding of the great changes iron manufacture has gone through during the last 70 years. Since the amelioration of communications in Carinthia, and the introduction of coal as fuel for the forges, the number of the latter has decreased from 106 to 21, and, while before this time no valley could be found which did not contain at least several forges, the whole production is now concentrated at 12 points only, where all conditions for the prosperous development of this industry are met with. And all this has taken place while the production of Carinthia has increased, in consequence of the rising demand, from 6,500 tons, produced in one time by 292 forge fires, with 295 hammers, to 25,724 tons of iron and steel products, 440,000 scythes, and 45,000 tons of pig iron per year, a decisive proof that it was not the decreasing demand, but the unfavourable situation of most of the old forges only, which caused their ruin.

In quite a different state may be found the iron industry of Sweden, where communications even now are difficult, the present conditions being much the same as they were in Styria 80 years ago. There we find a quantity of small forges distributed over the whole ore district, and, as the excellence of the articles produced insures constant customers, the forges carry on an uninterrupted, but weak business, owing to the want of sufficient facilities for communication, which, prohibiting the supply of fuel from any great distance, enhances the transport of large quantities of products to the nearest market-place, thus restricting the production in proportion to the quantity of fuel and ore which can be had in the immediate neighbourhood. Thus we find that nearly the whole production of wrought iron in Sweden is manufactured in no less than 827 forge fires, which produced only 187,791 tons of bar iron in the year 1871.

Even now the organisation of the iron industry is not completed, and great care must be exercised, and a very judicious examination of all interfering and assisting conditions, must take place when new establishments for the manufacture of iron products have to be created; for many expensive trials, as well as disastrous undertakings, have been originated from want of sufficient care in the study of the preliminary questions.

From the date of the introduction of rapid and efficient communication, when the various iron manufacturers of even the remotest districts were able to enter into competition, may be counted the numerous and most valuable inventions for simplifying the different modes of manufacture, for enlarging the yield of the establishments, and for economising in labour, fuel, and all other matters necessary for the production of the desired articles. In fact, what we are entitled to call the scientific and practical progress of iron manufacture, is in the closest connexion with what we may designate "free trade of communication." By this agency alone we are able to find out the best dispositions for the development of this industry, as given by Nature, and the amount of talent and energy that has been bestowed upon the elimination of unfavourable influences, and the utilisation of all, even the least, of the advantages that could be gained. At the present state of development there are two great principles which, from a commercial point of view, rule the mode of manufacture of all iron works, namely, the production of large quantities of an average quality and low prices, and the production of small quantities of very superior quality and high prices.

The choice of these two principles, in very exceptional cases only, is left to the iron manufacturer alone, as the first necessitates the outlay of a large

amount of capital, and is conditioned by the possibility of obtaining the requisite number of workmen at wages sufficiently low to enable successful competition. The second is by its nature itself bound to certain localities and conditions quite out of the ironmaster's control.

But few localities are to be found where the second principle can be carried out with success, and accordingly it would have seemed probable that all ironworks situated in such favoured districts should adhere to the manufacture of the best marks of iron; but the result has proved that, partly from commercial conditions, partly from the general tendency of the iron industry, many of such ironworks have taken up the first system, and the manufacture of first-class articles is thus confined to very few places as compared to the total extent of the production.

It is from the two independent points of view above stated that we must judge the exhibits shown in the Vienna Exhibition, if we do not wish to be reproached as unjust and incorrect critics.

We are quite aware that many of our readers will think that these introductory remarks ought to have been put at the head of our introductory remarks to this section; but if we consider that iron, only in the malleable form, has armed the hands of our ancestors and shielded their bodies, as it has given us the ploughshares which secure our existence, that all metallic structures we are producing at present, whatever form they may have, are only brought into shape by means of malleable iron, and if we carry in mind that even iron castings would be of very little use to us if we could not work them with chisels, drills, saws, &c., all made from malleable metal, we think it is but just to give the introductory review of the iron manufacture at the head of the present article. This is the more just also as the development of the iron industry did not begin with the manufacture of castings, but with the production of malleable, forgable material, and pig iron has to be looked upon merely as an intermediate product in the manufacture of malleable iron, but one which in itself has such advantageous properties as to make it fit also for direct use in the form of castings. According to the principles just enunciated, we shall be very careful in judging the exhibits of malleable iron exposed at Vienna, according to the ruling principle of the respective exhibitors, and hope thus to obtain a far more correct idea of the value of the exposed articles than would be the case by the ordinary mode of treating this important matter. But before entering into the subject we must give our readers an explanation why we propose not to divide the iron products according to the ordinary practice into wrought iron and steel, but into welded malleable iron and cast malleable iron. This division is a very important one, and will aid us materially in the judgment of the articles according to the two principles of manufacture as stated above.

It is a well-known fact that iron is only malleable if it does not contain more than about 2 per cent. of carbon, which per-centage corresponds to the hardest steel, a material which, under certain circumstances, may yet be forged; but for all common forging purposes iron containing more than 1½ per cent. of carbon will be useless, the weldability being lost with 1·75 per cent. of carbon.

This characteristic feature is exactly the same, whether the malleable iron be fibrous or homogeneous, whether it be produced direct from the ores, or in forge fires or puddling furnaces by decarburisation of pig iron, or by any process yielding the metal in a liquid state, as in the Bessemer converter, in the Siemens-Martin furnace, or in crucibles.

If containing less than from 1·75 to 2 per cent. of carbon, but more than from 0·25 to 0·35 (according to the quality of the ores and the process of manufacture), the malleable iron produced is usually called steel, and when containing less than the above amount of carbon it is called wrought iron. The mode of manufacture having no influence at all upon this nomenclature, which is merely a designation of a certain amount of carbon in the iron, we find steel of welded structure (called puddle steel, forge steel, &c.), as well as of perfect homogeneity (called cast steel, crucible steel, Bessemer, or Siemens-Martin steel, &c.), and malleable iron of welded structure (called commonly wrought iron, puddle iron, bar iron, forge iron, &c.), as well as of perfect homogeneity (called Bessemer iron, Siemens-Martin iron, &c.).

But as, on the other hand, the process of manufacture of the so-called steel

and iron has the greatest influence, not only upon the degree of malleability or the hardening properties, but also upon the physical peculiarities of the product, and as these peculiarities are nearly of equal character for all sorts of malleable iron produced by such processes as will yield a welded product, and again quite different from the peculiarities shown by malleable iron manufactured by processes giving a homogeneous or molten product, we will divide the malleable iron products according to their physical properties and appearances into two sections, namely:

1. Welded iron, including forged iron, forged steel, puddled iron, puddled steel, cemented steel, &c.

2. Homogeneous iron, containing all products obtained by perfect fusion of the manufactured metal.

This division is really one of much practical value, as it is one which allows of no misunderstandings and controversies, whereas the limit between wrought iron and steel cannot be fixed properly, changing with every sort of iron, and is thus always giving rise to useless discussions. On the other hand, most of the differences in our modern iron constructions are based upon this discussion, as a brief review of the principal objects of iron manufacture will prove.

Steel boilers differ from wrought-iron boilers in the quality of the material, which, in the former, is exclusively homogeneous iron or steel, as puddled steel has not been used to any extent for boiler plates.

Armour plates are found only to answer well if welded iron is used; homogeneous metal used for this purpose has been proved to crack like glass.

Tyres are assorted according to their material being welded (puddled) steel, or homogeneous (cast) steel.

Rails are analogous to tyres.

Bridges, to no small extent, are now made of steel, but no engineer would take welded steel, as in such a case homogeneous material is the only one used.

Guns, if made of malleable iron, are either constructed of welded iron, or homogeneous iron, quite irrespective of the degree of hardness of the metal.

Tools are now exclusively made of homogeneous cast steel.

Steel disc wheels are exclusively manufactured of cast steel.

Axles, in many places, have been found to answer far better if made of homogeneous metal than of welded material of the same quality, and the same degree of hardness.

We could enumerate many more examples where the physical property of homogeneous iron against welded iron has been decisive in the adoption of one or the other of the materials; but as we shall have sufficient occasions to lead the attention of our readers to this important point in speaking of the exhibited articles, we will hasten to the main subject in view, and begin with a critique of the welded iron and its products exposed in the Vienna Exhibition.

Products or samples of welded iron were exhibited by nearly all countries, not even China or Japan excepted, and this is the more easily to be understood when we take into consideration that this form of iron was the oldest known, and was produced a thousand years ago with nearly the same apparatus, and by the same method, as we find it to be manufactured now-a-days in the remote and uncivilised countries of our globe.

Apart from its universal employment, this form of iron deserves our special interest, as in it the characteristic features of the value of the material for purposes of common utility, in short, the quality of the iron, are far more striking, and of far more easy detection, than in the form of homogenous metal. The iron articles shown at the Vienna Exhibition gave us such an excellent opportunity for proving this statement, that it would be a perfect misunderstanding of the value of international exhibitions if we did not take it up, and draw an interesting parallel between the iron products of the different countries.

Perhaps nowhere except in Asia and Africa, and some parts of South America, is a direct process for the production of welded iron or steel from ores at present practised, and therefore, as iron articles mostly are exhibited by European or North American iron masters, we cannot expect to find much which would be worth while to attract our attention to the direct process of manufacture.

Nevertheless, we are bound to state that we found in the Indian department a complete model of an Indian forge, which, for some reason or other, had been placed below a table containing principally samples of rock salt, and which thus escaped the notice of most visitors. This model conveyed a very good idea of the process, which was further illustrated by some samples of iron blooms and bar iron manufactured according to this method.

In the Chinese department, a collection of ores, from the province of Fo-kien, and of blooms and bar iron manufactured therefrom, was exhibited by the manager of the Imperial Chinese Arsenal, at Fou-Tcheou, and as, so far as we are aware, the process of manufacturing malleable iron in China has not yet been described, we will give a brief account of the method used there, according to the statements of M. Prosper Giquel, the manager of the above-named arsenal.

The ore used for the manufacture of iron in China is found in large quantities in the province of Fo-Kien, opposite to the Island of Formosa, and consists principally of a very fine sand, which is the result of the successive disintegration of the granite rocks of the country intimately mixed with fine particles of magnetic iron ore. This mixture, after having been washed off the original sites of its components on the eastern declivities of the Tajuling mountain range, is deposited in the lower parts of the country, and gathered there by the inhabitants.

This sand, after having been collected, is submitted to a process of separation, by means of which the heavier particles of magnetic ore are collected on the bottom of the washing reservoir, and taken out successively. This process of washing the sand will yield from 1½ to 2 per cent. of magnetic ore out of the whole mixture, the ore having the appearance of a dark, greyish brown sand. The magnetic ore is then treated in small furnaces made of clay, and armed with iron rings of a tapered section. The blast is furnished by wooden blowers actuated by men. In filling the furnace, ore and charcoal are taken in equal weights, when the blast is put on, and the whole mass brought to a smelting heat. The yield of the ore is a very poor one, as 500 lb. of the magnetic ore sand will only give 150 lb. of reduced iron.

The product of the operation is a regulus of reduced and smelted iron intermixed with particles of slag, charcoal, and cinders, which is treated again in the same furnace with about 50 per cent. of its weight of charcoal, after which operation a bloom of more or less steely iron, weighing 83 lb., will be obtained. Before cooling, the bloom is hammered down into bars of about 1 in. square, which subsequently are cut to lengths of 6 in., when the material is ready for market. It is in this form that the arsenal at Fou-Tcheou buys the puddled iron from the inhabitants.

It will be seen that the iron thus obtained is very impure, and must undergo a further preparation in a reheating furnace and under the forge hammer, before it can be used for forgings, or for the manufacture of bar iron in rolling mills. By this last reheating and welding operation the puddle bars are again reduced to about 75 or 80 per cent. of their original weight.

The price of the puddle bars brought from the Chinese, and delivered at the arsenal, is 11*l.* per ton of 1,000 kilogrammes. To this price must be added the cost of reheating and welding under the forge hammer, as well as the loss incurred in this operation, in order to obtain a basis of comparison with the prices paid in Europe for bar iron.

The manager of the Fou-Tcheou Arsenal anticipates that he will be able to use this iron as a substitute for Lowmoor iron in boilers, &c.; but the appearance of the bar iron manufactured at the arsenal and exhibited in Vienna does not seem to justify such hopes, as the fractures of the metal show a material not thoroughly welded, and of a very doubtful homogeneity.

This Chinese process of manufacturing welded iron is curious, in so far as it is a combination of the blast furnace process with that of a forge fire. It would be interesting to know in what way the ore is added to the incandescent mass of fuel, as the fine sandy form would not allow its being put into the furnace at once, as it doubtless would occasion the stoppage of the blast.

As our readers will have noticed, the loss in this process is an enormous one, as 500 lb. of magnetic iron ore ultimately yield only a badly welded

bloom of not more than 83 lb., which corresponds to about 17 per cent. of the ores used, so that if we take the per-centage of metallic iron in the magnetic sand at only 50 per cent., we find that the loss of metallic iron is about 66 per cent. of the original contents of the ores.

We now come to the review of the welded iron manufacture in Europe and America, where the direct process has long ago been abandoned, and where blast furnace pig iron forms the raw material from which all welded or wrought iron is produced by processes having for their object the elimination, by the use of oxidising agents, of all impurities chemically contained in the pig metal. Up to the present, two principal methods only may be said to exist for obtaining this object—the refining in forge fires, and puddling furnaces.

Other processes for the elimination of carbon, silicon, sulphur, phosphorus, &c., from pig iron, have up to the present had no practical success, and moreover, no exhibits were to be found in Vienna of welded iron manufactured by any other than the two named processes. Before beginning our review of the welded iron products exhibited in Vienna, we must acquaint our readers with some characteristic features of the chemical properties of welded iron, regarded from a point of view which, though beginning to be generally adopted, has not yet become sufficiently estimated as the only one allowing of a clear unprejudiced examination of the real value of the manufactured articles.

The characteristic feature of welded iron is its lack of homogeneity, which is due to the system of manufacture, as the semi-fluid state of the metal when it "comes to nature," prohibits the perfect separation of the iron particles from the adhering cinders and the particles of slag surrounding the metallic iron. The finished forge or puddle bloom, therefore consists of a quantity of iron particles which, more or less, have the form of small balls welded to others at different parts of their circumference, while the interstices are filled with slag and cinder, as shown in the sketch, Fig. 10, Pl. XXXIV.

It is clear that if such a bloom is hammered down or rolled out to bars, the iron particles will be stretched, to a certain extent, especially when the bloom is elongated by means of rolling. The particles of cinder between the iron globulæ, will only be able to be squeezed out if a communication exists to the surface of the bloom; but in all other cases, or where the cinder is only fusible at a very high heat, as is the case when pure oxide of iron or magnetic iron (a product of oxidation of the iron particles in the furnace when not covered with slag) fills the interstices, expulsion will be impossible, and iron globulæ, as well as interstices, will be elongated conjointly by the process of forging or rolling, as shown in Fig. 11, Pl. XXXIV. This will produce what is generally called fibrous iron, in opposition to granular iron, where the expulsion of foreign matter has been carried out to perfection, and far more parts of the original iron globulæ have been welded together. This proves that granular iron cannot be obtained merely by compressing the bloom at a welding heat, as the welding of the particles of iron must take place in the puddling furnaces before the cinder has filled the interstices.

Now we know that there are impurities in chemical combination with the pig iron, which affect very materially the welding properties of the refined metal. Sulphur will prohibit, phosphorus will facilitate, welding, all other conditions being equal; therefore, we find that all iron containing sulphur will give fibrous malleable iron, while phosphorus contained in the pigs, if not counteracted by sulphur, will yield a crystalline or granular structure, like pig, containing neither one nor the other of the impurities.

As the strength of wrought iron evidently consists in the metal, and not in the particles of slag or cinder contained, the best iron, if strength is required, will be a granular one. We need only give here the results of trials made in 1867 by the Earl of Dudley, according to which:

	Tons per sq. in.
Fibrous iron, common quality, broke with a strain of	23¾
„ best	24
„ best best	25
„ treble best	25
Granular	28

It is known that a per-centage of phosphorus of about 0·5 will make wrought iron brittle; therefore granular structure derived from the presence of phosphorus is in no way a desirable appearance. Consequently, the best granular iron must be free from sulphur and phosphorus; at least to such a degree that the per-centage of these impurities is unable to affect the quality of the product. The second condition for the manufacture of strong granular iron will be a very liquid slag in the puddling furnace, this slag being then easily removeable by squeezing the bloom during the balling operation. From what has been said we may derive very interesting and instructive conclusions, very useful for obtaining a correct judgment of articles belonging to this class of iron:

1. By the imperfect processes of manufacture our ancestors were unable to produce granular iron, and therefore a strong belief prevailed that the fibrous structure of bar iron was a characteristic feature of a good product.

2. Ores free from sulphur and phosphorus, and with a liberal amount of manganese, will nearly always yield a granular iron if properly treated in the refining process, as was to be seen by inspection of the Swedish forge blooms and samples of bar iron exhibited in Vienna.

3. As sulphur can be eliminated in the blast furnace, but phosphorus contained in the ores will always enter in combination with the pig iron, sulphurous ores are far less dangerous than phosphoric ores for producing strong granular iron. The ores of Dannemora, yielding the well-known excellent quality of wrought iron, do not contain more than 0·006 per cent. of phosphorus, and 0·038 per cent. of sulphur, on an average. Dannemora iron is always of granular texture.

4. In cases where weak iron has to be used for purposes where the metal has to undergo bending when cold, fibrous structure may be very useful, as the interposition of slag bands allows of a sliding movement of the fibres one over the other, like a bundle of branches which can be bent without fear of breakage to an extent quite unapproachable by a solid mass of wood. This is the reason why many of those forges which treat impure ores, or pig iron of inferior marks, are bound to produce fibrous iron to make it marketable. These works, too, are the most assiduous defendants of fibrous texture in bar iron—well aware that if a more correct view of the question should become popular they would be obliged to stop their works.

5. Nothing is easier than to produce fibrous iron, merely by prohibiting the expulsion of impurities during and after the puddling process. We have made very interesting trials with respect to this subject. Several bars of puddled iron of perfect granular structure were placed so that all adhering cinders were removed, and a pure metallic surface was obtained. These bars were cut to lengths of about 2 ft., and two sets of piles were made. The piles of one set were put together in the ordinary way (Fig. 12, Pl. XXXIV.) The piles of the second set, however, were put together with layers of hammer slag $\frac{1}{4}$ in. thick between the bars, and the whole pile put in a case of iron plates to prevent the hammer slags from falling out during the reheating process (Fig. 13, Pl. XXXIV.) Both piles were rolled out to bars 1 in. square. The first set gave granular iron without any signs of fibre; the second showed alternate layers of granular and fibrous texture, the latter corresponding to the layers of hammer slag between the puddled bars, as shown in Fig. 14, Pl. XXXIV.

6. Granular iron never will become fibrous by mere elongation of the piece subjected to work, except when a proportionately very great reduction of the original section is produced by working the metal when cold, as is the case in the manufacture of wires; but here, too, the metal does not undergo a change in its physical properties. The welds of the iron globulæ, even in granular iron, never will be so perfect as to insure real homogeneity of the metal. Now, by drawing out an iron bar to wire the globulæ will, of course, be elongated, and every particle of the section will have to move in the direction of the tension. Naturally, if a weld is not perfect, this will be the weakest part of the section; and according to a very simple law of mechanics this very weld will become a sliding plane. The finer the wire the greater the stress on the welds, and the more fibres there will be in consequence. If such a wire could be rolled out at a welding heat, no fibres would be seen if the original bar did not contain them. Weak parts will

also occur in homogeneous metal, even in cast steel; and especially soft marks, containing more or less of diffused particles of oxide, will sometimes become apparently fibrous, as we shall see subsequently.

7. The greater the amount of impurities in the iron the shorter the fibres will be, as may be understood by inspection of Fig. 11, Pl. XXXIV., where, on the left side, many of the globulæ have been welded together, seemingly producing long fibres, whereas on the right portion at *m n* the globulæ have been welded only on some parts of their circumference, showing the appearance of the original length of the elongated iron particles. It will not be necessary to prove that the former half of the iron bar shown in Fig. 11 will be by far the stronger portion of the two.

8. For all purposes where strength and elasticity, and before all, great reliability of the material is wanted, good granular iron will be far more advantageous than the so-called best fibrous iron. But where iron is only wanted as a cushion for impact, as is the case with armour plates, iron containing the greatest amount of impurities and cinders, provided it will weld, proves to be the best. It is a well-known fact that under such conditions compact granular or homogeneous cast malleable iron will behave like glass, as compared with the spongy fibrous iron commonly used. This explains the failure with Swedish or Styrian iron armour plates. At every shot the latter were scattered to pieces, while the fibrous English plates were simply perforated without any damage of the adjoining parts. These results are explained by the fact that all Swedish, and most of the Styrian iron is of granular texture, owing to the great purity of the ores, and to the high amount of manganese, all these properties tending to produce perfect welds between the iron globulæ of the puddled bloom.

From the points of view enunciated under the heads of these paragraphs, we shall have to deplore all tendencies to produce fibrous iron where not necessitated by the inferior quality of the raw materials used, or by the specific object in view, and these principles will have to guide us in the critique of the exhibited articles. Indeed, we found the characteristic feature of the exhibited wrought-iron articles of Sweden, Russia, and Austria to be, with few exceptions, a granular texture, while the bulk of fibrous iron is to be found in the French, Belgian, and German departments.

The manufacture of wrought iron in Sweden, as we have stated, is carried out nearly exclusively in forge fires, called Lancashire forges, there being only five iron works, viz., Motala, Surahammar, Nyberg, Gunnebo, and Kallinge, where puddling furnaces are used. The forge fires have two tuyeres, and the blast is admitted under a pressure of $3\frac{1}{2}$ in. of mercury, while its temperature varies between 210 and 390 deg. Fahr. The common charge is from 68 to 128 kilogrammes (150 to 282 lbs.) of mottled pigs, containing on an average 4 per cent. of carbon, from 0·1 to 0·4 per cent. of silicon, and from 0·01 to 0·03 per cent. of sulphur. The loss in these forge fires is 13 per cent., and the consumption of charcoal varies from 4·6 to 6·6 cubic metres (495 to 710 cubic feet) per ton of blooms produced.

The blooms, after having been compressed and welded up under steam or water hammers, are then reheated in separate furnaces, most of these being Siemens regenerative gas furnaces, in which peat, common coal, or even wood and charcoal are used as fuel. The hammered blooms are not piled before reheating, as is done in nearly all other iron works, but each bloom is worked out separately into bars, and only where large forge pieces are wanted are several blooms welded together.

This system of working, which is based upon a perfect knowledge of the results obtained in welding several bars of iron together, and which perfectly corroborates our views expressed in our last article, is necessarily quite opposed to the production of fibrous iron, as the interposition of impurities by piling is carefully avoided. Consequently we find that all the iron bars exhibited by the different Swedish works were of a perfect granular structure, notwithstanding the well-known strength, tenacity, and general excellence of the products.

The works of Mölnhacka exhibited at Vienna an excellent series of bar-iron sections, confirming the above statements. We found analogous results also in inspecting the articles exhibited by the well-known works of Dan-

nemora, Forna, Degerfors, Wicksmanshyttem, Hammarby, Finspong, &c. On the other hand, we must not forget that the great purity of Swedish ores facilitates the manufacture of granular iron, while its tensile strength and tenacity, and the perfect homogeneity of its texture, proves the perfect weldability of the material.

We give, in the following table, the average contents of sulphur and phosphorus contained in the ores used in some of the above-named works, in comparison with some others used on the Continent :

AVERAGE PER-CENTAGES OF SULPHUR AND PHOSPHORUS IN THE FOLLOWING ORES.

Name of Works.	Name of Ores used.	Per-centages of Sulphur in the Ores.	Per-centages of Phosphorus in the Ores.
	Magnetic ore from :		
Hammarby - -	Rastelp - -	0·011	0·0006
„ - -	Pershyttau - - -	0·007	0·013
„ - -	Lerberg - -	trace	0·0013
Forna - -	Marnäs - - -	—	0·007
„ - -	Hilläng - - -	0·02	0·005
„ - -	Prague, Byberg, Ejetterbück, and Nyberg - - -	0·081	0·017
Finspong	Färola - - -	0·06	0·01
„ - -	Nartorp - - -	0·07	0·016
„ - -	Stenebo - - -	0·09	0·03
Dannemora - -	Dannemora - - -	0·037	0·006
Some ores used in Prussia.*			
Various works.	Red hematite near Wiesbaden	trace	0·31
	„ „ Coblenz -	trace	0·20
	Brown „ „ -	0·08	0·15
	„ „ Wiesbaden	trace	0·21
	Spathic ore „ Limburg -	0·60	0·017
	„ „ Oberlahn -	0·32	0·012
	„ „ Werbenbch.	0·564	0·010
	Black band „ Westphalia	0·20	0·36
	Bn. hmtite. „ Rhine prov.	—	0·09
	„ „ Westphalia	—	0·42

* These analyses were taken from the exhibition of analysed ores in the German Department.

From this table it will at once be seen that the great per-centage of phosphorus contained in the German ores, as compared with those of Sweden, though advantageous to the welding of the iron produced, will not allow of the manufacture of granular iron, as the result would be a cold-short, useless material. In this case, therefore, a fibrous product must be manufactured to obtain a certain amount of tenacity and flexibility when cold, for reasons which we have already explained. Indeed, we find the tendency in the Rhine districts to be mostly towards the production of fibrous iron.

In Sweden the necessary fuel for reheating the blooms averages from 1·9 to 3·7 cubic metres (205 to 399 cubic feet) of wood, or from 0·25 to 0·6 cubic metres (2·7 to 6·5 cubic feet) of coal in common reheating furnaces; but in cases where Siemens furnaces are used, only 1·8 to 2·5 cubic metres (19·4 to 27 cubic feet) of wood, or from 3 to 4·3 cubic metres (32·3 to 46·3 cubic feet) of air-dried peat, or about 6·8 cubic metres (73·2 cubic feet) of sawdust are necessary per ton of bar iron produced.

In working out the bars under the hammer, the waste has been found to average about 12 per cent., whereas in rolling them the waste is only 9 per cent. The wages for the refining operations in the Lancashire forges vary

from 8*s.* to 10*s.* 8*d.* per ton of forge bloom, and those for reheating and hammering or rolling, from 8*s.* to 12*s.* 8*d.* per ton of bar iron.

Puddle steel is only manufactured at Surahammar and Motala, the use of this material being very limited. Motala and Smedjebacken are the only two works where rails can be rolled, the former produced 2,137 tons of puddled steel and Bessemer rails, in 1871; and the latter only 1,083 tons in the same period. The increase of the export of Swedish iron has been very rapid during the past ten years, as will be seen from the following table:

Materials.	1860.	1865.	1870.	1871.
	Tons.	Tons.	Tons.	Tons.
Pig iron exported - -	12,725	16,018	39,940	41,085
Iron blooms (puddle bars)	1,821	3,936	7,907	10,423
Bar iron - - -	97,657	89,553	135,331	143,335

From what has been said it will be seen that the manufacture of welded iron in Sweden is carried out on the principle of obtaining excellent quality with limited productions, and this probably, after all, will be the ruling system for some long time to come.

Very analogous conditions are to be found in Russia, but here the results have been somewhat changed by the fact that the enormous distances of the different manufacturing districts from each other, and from the nearest places of consumption, have necessitated a certain concentration of the iron works at the places where the large ore deposits of this vast empire are situated; so that we find the main groups of iron works at the western descent of the Oural, near Moscow, in Poland, and in Finland. In the Oural, with the Altai, and the mountain ranges of Nertchinsk, are found the chief mineral riches of the Russian Empire, whence it derives its sterling coin, as well as its silver and platinum, its far-famed iron ore, and to a great extent its wealth and power.

These districts abound with forests, so that mineral fuel has only very recently been employed in metallurgical processes. These vast stores of charcoal facilitated to a great extent the manufacture of the excellent quality of welded iron with which we met in the Exhibition. To give our readers an idea of the enormous quantities of wood and charcoal which are annually used in metallurgical operations in Russia, we need only state that about 750,000,000 cubic feet of wood, and about 1,500,000 tons of charcoal are consumed per annum.

The great distances of the iron districts from the centres of population also account for the slow progress in the Russian iron industry when compared with the rapid increase of production in Sweden.

Materials.	In 1830.	In 1840.	In 1850.	In 1860.
	Tons.	Tons.	Tons.	Tons.
The production of pig iron was - - -	182,948	180,400	227,549	297,691
Welded iron - -	—	114,228	163,791	183,580

There is no doubt that the disadvantages arising from the great distances to be traversed by the manufactured products before reaching their destinations, will rapidly be overcome by the construction of a network of railways, of which at present a length of 8,923 miles is completed. As to the different examples of welded iron exhibited in Vienna, they all showed a remarkable quality of the material; for in Russia as in Sweden, the difficulties which attend the delivery of the manufactured products at any great distance necessitate the production of the very best marks only, as even a middle sort would

not even repay the expenses of transport. Most of the bar irons exhibited at Vienna had a granular texture ; a proof of the purity of the iron.

Prince Paul Demidoff exhibited an excellent series of examples of welded iron commencing with a large bloom, and ending with the well-known thin Russian sheet irons with black shining surface. Prince Demidoff's works and property are situated near Perm, Nijni-Taguil, in the district of Verkhotourié, and they comprise an area of 1,710,000 acres, out of which about 1,430,000 acres consist of forests. The works produce 5,800 tons of bar iron, 7,400 tons of sheet iron, and 5,300 tons of rails per annum. Besides this some steel is manufactured.

Prince Constantin de Belosselsk exhibited some very good samples of welded iron in the form of bars of different sections. The works of Countess Henbock Fermor at Verkh-Issetsk, and those of Messrs. Rastorgoueïff, at Ekatérinburg, manufacture large quantities of bar iron, and polished as well as unpolished sheet iron of great resistance and elasticity.

Besides these and the imperial manufactory at Perm, several other exhibitors of minor importance showed, all in more or less complete collections, the same or nearly the same quality of the material, though we cannot deny that the exterior of nearly all exhibited samples would have been much improved, and would have been much more satisfactory to the eye if, as in the case of Sweden, some care had been bestowed upon the general arrangement, and the periodical cleaning of the articles exhibited.

We now come to the Austrian department, and as the exhibition of welded iron in it was by far the most complete in the whole Exhibition, while on the other hand, the Austrian iron industry is not only interesting in itself, on account of the very exceptional conditions of manufacture prevailing in that country, but moreover is of great importance to English iron manufacturers on account of the business relations between the two nations, we propose to deal somewhat fully with the characteristics of the iron industry in Austria, and the prospects of improvement anticipated by many of the leading authorities in the Austro-Hungarian Empire.

Austria has been generally termed, by some of its inhabitants of rank and knowledge, an "iron country," that is to say, a country where the iron manufacture with all its branches is not only the ruling industry of the land, but also its principal and most natural source of wealth and international commercial transactions. We shall not deny the correctness of the statement as applied to certain parts of Austria at the present moment; but in discussing the question critically, we can hardly agree that the term of "iron country" can be applied in the full sense of the words to Austria in general, or to most of its parts for the future. In fact we find that the difficulties arising from the unlucky distribution of fuel, ores, and places for consumption, are increasing from day to day as far as the production of large quantities of welded or malleable iron is concerned.

Referring first to the materials required for the manufacture of welded iron, we find that the puddling works have to contend with two very great difficulties, namely, first, the want of the necessary pig iron, which in scarcely any instance is manufactured in sufficient quantities on the spot where the puddling operations are carried on, either from the want of ores or fuel; and secondly, the want of proper fuel. The ore deposits in the neighbourhood of which the pig iron is manufactured, being generally very far from the places where cheap and good coal can be obtained, the puddling and refinery works have no other chance than to be distant from either the iron or coal districts, or to be near neither the one nor the other. This singularly complicates the great question of improving the manufacture of large masses of refined material, and at the same time has created an impression in some quarters that there exists a great want of pig iron over the whole country. The construction of many blast furnaces of very large dimensions has lately been the consequence, as for instance, two blast furnaces of the Innerberger Company, at Schwahat, constructed upon the Büttgenbach system, for a production of 50 to 60 tons a day each, a blast furnace of similar dimensions at Ostrau, in Silesia, and two others on Scotch models, at Trzienitz and at Wittkowitz. One is also in course of

construction at Rakycan, Bohemia, and we believe half a dozen more at Sbirow, the property of Dr. Stroussberg.

But if we follow the returns of the Imperial Office for the four years 1868–71, we find that the importation of pig iron, of castings, and malleable iron (welded and cast) increased in the following proportions :—

——	1868.	1869.	1870	1871.	Remarks.
	Tons.	Tons.	Tons.	Tons.	Tons of 100 kilo.
Pig iron, broken castings, &c.	131,351	154,614	160,919	193,650	
Castings in general -	9,700	37,650	39,850	39,400	
Malleable iron and steel -	77,500	153,550	151,150	139,398	

If we bear in mind that nearly three tons of pigs are wanted to produce two tons of wrought-iron or steel articles, and that large quantities of mill bars have been imported under the head of pig iron, the duty being the same; it will be found that the increase in the import of pig iron is by far less in proportion than that of malleable iron, which tends to show that Austria is far less in want of blast furnaces than of puddling or refinery works capable of sustaining foreign competition. If this is really the case, and all facts seem to prove it, then the construction of so many blast furnaces without the corresponding erection of finery works able to compete with Germany and England, at least for the Austrian market, marks an entirely false movement, and great losses with these blast furnaces will be inevitable.

Now the exhibition of welded iron material in the Austrian department showed that there seems to be very little chance for iron works manufacturing welded iron products of inferior quality, such as rails, &c., to be able to compete with English or German works, except when there is an extra demand for such articles, as was the case during the past two years, when no English or German firm could take large orders for Austria, being themselves overwhelmed with work. Indeed, according to what has transpired of the experience of the possessors, the two largest refining works in Austria and Hungary are yielding very unsatisfactory results, and even other works on a smaller scale, and far nearer to the centres of the pig-iron manufacture, are said to be in no less disagreeable positions.

Of course it must be well understood that all that we have just said refers to the manufacture of large masses of an average or inferior quality at low prices; the manufacture of high-class products, on the other hand, is always limited, as we stated in a former article, and in Austria this branch of the iron trade will maintain its well-known position if the proprietors of the works devoted to it do not want to join the great run after the first principle of large production of inferior quality, which we fear many of them would like to do.

There exist, at present, three great centres for the iron manufacture in Austria, viz., Bohemia, with a yield of about 130,000 tons; Styria and Carinthia, giving about 178,000 tons; and Upper Hungary, with, at least, 100,000 tons of pig iron per year. Besides these centres, there exist two others of less importance and compactness, viz., Moravia and Silesia, with a production of about 33,000 tons, and the Lower Hungarian districts with nearly the same production. Some smaller works are dispersed over some other parts of the country, but have no influence upon the general trade combination. Of all these centres there are only those of Bohemia and Silesia which are placed near abundant coalfields. The Lower Hungarian district, which also benefits from the neighbourhood of large coalfields, does not come into consideration, as being much too far off from the present centres of consumption, while, moreover, the greater proportion of the coal found there does not coke. As for the Upper Hungarian and Styrian districts, the two principal ones, as far as the quality

and quantity of ores are concerned, are a long way removed from any coalfield worthy of consideration.

This being the state of the case, the refinery works must necessarily pay large sums for the transport either of the pig iron or the coal; and, moreover, as the large coalfields of Austria are nearly all situated on the frontiers of the country (on the frontier of Bohemia, near Saxony, on the frontier of Silesia, near Prussia, on the frontier of Transylvania, near Roumania, and in the southern part of Hungary), at a great distance from any market, it follows, of necessity, that the puddling works, rail and plate-mills, as well as the steel manufacturing works, will always, under all circumstances, have to contend with heavy freights.

The only centre where this is not the case is, as we have already stated, in the Bohemian district, but there the ores are not abundant, and their quality is doubtful, while the coal, as well, is very impure, and contains a large per-centage of ashes. The Silesian centre is in possession of excellent coal, but the ores must be transported from Upper Hungary, a distance of about 150 miles.

Under such circumstances it will be very difficult for the Austrian iron-masters to beat foreign competition for a long time to come; and we, therefore, believe that Austria, however rich in ores and fuel it may be, will, for a long period at least, remain an open market for English manufacturers.

The manufacture of welded iron in Bohemia was, up till 1865, carried on mostly in forge fires of different constructions, but at present hardly any of the works have been able to resist the introduction of puddling furnaces. In Styria there are now about 100 forge fires at work, on account of the high quality of the product gained, and there the transformation into puddle furnaces will not be as quick as in those parts of the country where only inferior ores are found. In Bohemia, at Liditzau, in the year 1843, and in Styria, at St. Stefan, 25 years ago, trials were made to manufacture wrought iron directly from the ores, but the economical results were not encouraging, and this system was entirely abandoned. Mr. Siemens' process will be of the greatest value in the Styrian and Carinthian districts, as well as in those of Upper Hungary, where fuel is very scarce, and no coking coal can be obtained.

All the iron manufactured in Bohemia is, as a necessity, of a fibrous texture, arising from the inferior quality of the raw materials. In Styria we find all welded bar iron to be granular, it not being necessary to make it fibrous for the sake of tenacity and resistance to bending strains; but it is a well-known fact that owing to its purity and granular structure, out of which great compactness arises, the Styrian as well as the Carinthian iron has a greater resistance against bending when cold than the less pure but fibrous Bohemian bar iron. On the other hand, Styrian iron is well-known for its welding properties, which are unsurpassed by any other material, while Bohemian iron must be treated with the greatest care when hot. We also found in the exhibition of Styrian iron manufacturers that all wire manufacturers use iron of exquisite granular texture, as no fibrous iron would stand the test of being drawn out cold.

The Bohemian puddling furnaces, using slack coal from the Silesian and Upper Silesian basins, give the following results in the manufacture of common mill bars, slack coal being used:—

	In Single Puddling Furnaces.	In Double Furnaces.
Pig metal charged per 100 lb. mill bars	114 lb.	114 lb.
Coal slack used per 100 lb. mill bars	135 „	95 „
Yield per week	13½ tons	20 tons.

In manufacturing puddled steel the materials used per 100 lb. mill bars, and in a single puddling furnace are as follows:—

	lbs.
Pig metal - - - - - -	116½
Coal slack - - - - - -	140

Yield per week, 12 tons.

At the works at Rossitz, near Brünn, in Moravia, where coal is found on the spot, and used in the puddling furnaces, the results are less satisfactory, 118 lb. to 122 lb. of pigs, and 127 lbs. to 135 lb. of coal being necessary to produce 100 lb. of mill bars. At Bras, in Bohemia, they only use 112 lb. pigs, and 120 lb. of coal per 100 lb. of mill bars.

In Styria a great variety of puddling furnaces have been introduced, as the absence of good coal necessitated the use of brown coal or peat. For the use of the latter material, especially, which is found at many places in the Alps, Siemens' regenerating furnaces have been introduced with success.

At the works of Neuberg, in Styria, where double furnaces are in use, 111½ lb. of Styrian pig iron, and 119 lb. of brown coal, will yield 100 lb. of mill bars, but only six charges, of about 900 lb. each, are made per twelve hours.

In general, however, in producing mill bars out of the common Styrian puddle pigs, a single puddling furnace, with three workmen and a boy, will produce, within twelve hours, eleven charges of from 500 lb. to 600 lb. each of puddle bars of the first quality, and will use about 3 tons 11 cwt. of good brown coal; the loss of iron will be about 5 per cent. But at some works, where an inferior quality is aimed at, from twelve to thirteen charges of 600 lb. each will be made.

The puddle balls are usually rolled out to bar iron without piling, and the reheating furnaces will yield, within twelve hours, from 4½ tons to 8½ tons of bar iron, with a loss of from 15 to 17 per cent., and a consumption of about 4½ tons of brown coal.

When using the inferior quality of coal found in Styria, in several places the results are the following:—A furnace will yield, within twelve hours, and with three workmen, when puddled steel is produced, from eight to nine charges of from 100 lb. to 150 lb. each, with a loss of 7 per cent., and a consumption of from 230 lb. to 250 lb. of inferior coal per 100 lb. of puddled steel. Whereas, in producing iron only, eleven charges, of 500 lb. each, will be made, and 106 lb. of pigs, and from 220 lb. to 230 lb. of coal, will be necessary per 100 lb. of puddle bar.

When peat is used in Siemens puddling furnaces these will give, within twelve hours, from nine to ten charges of 400 lb. each, with a loss of 5 per cent., and a consumption of 16 cubic feet of air-dried peat, while the quantity of peat necessary in ordinary puddling furnaces is as much as 24 cubic feet per 110 lb. of puddle bars.

The principal objects of the wrought iron and puddled steel manufacture in Styria, are axles, plates for boilers and other purposes, sheet iron, wire, bar iron, forged articles, &c.; but wrought-iron rails, too, are manufactured in Carinthia, though not to a very large extent. In the last-named country there is a large production of nails and similar articles, as well as of some cemented steel for the Turkish and Asiatic markets. Bohemia, Silesia, and Hungary are the principal countries where the more common sorts of wrought and welded iron are produced, and, especially, rails are rolled in large quantities by the Prager Eisenindustrie Gesellschaft, who are the proprietors of the Kladno Works, near Prague, and who have produced during late years about 35,000 tons of rails, girder iron, bar iron, plates, and forged articles, per year.

The Wittkowitz Works, which in comparison to the other Austrian exhibitors were rather poorly represented at the Exhibition, are the property of Baron Rothschild, and with the Teschen Works, belonging to Archduke Albrecht, are together the largest manufactories of wrought iron and puddled steel rails in Austria. These two works are both situated in Silesia, close to the large coalfields of Ostrau. The exhibition of the Teschen Works was a splendid one, and reflected every credit upon the very able manager, Mr. Mayer.

Wittkowitz has an annual production of about 20,000 tons of rolled materials, such as rails, axles, plates, and bar iron. But this sum includes also a small quantity of Bessemer steel articles. The Teschen Works produce only welded materials, such as iron and puddled steel rails, boiler plates, sheet iron, angle irons, and all sorts of bar iron. The annual iron production is 16,000 tons.

Besides these works we may name those of Prince Fürstenberg, at Althütten, near Pilsen; of Baron Klein, at Stephenau and Zäptau; of Messrs. Bondy, at Prague, and the works at Neudeck, with a collective annual production of 32,000 tons of rails, girder irons, and bar iron.

In Hungary we met, besides several exhibits of small quantities of bar iron and similar objects, with the splendid exhibition of the Imperial States Railway in a separate pavilion near the eastern end of the main building. We have already had occasion to notice the most interesting display from this company's works at Resicza, Anina, Dognácska, and Orawicza, all situated in the south-eastern part of Hungary, commonly called the "Banat." The development of these works within the last few years is principally due to the excellent general management of Mr. Barré, the head manager of the mining and iron properties of the company, and of Mr. Gabriel, his first assistant engineer.

The main works are those at Resicza, a property comprising a total area of about 91,000 acres, of which about 60,000 are forests for the production of the necessary charcoal for blast furnaces. The puddling works contain 11 puddling furnaces, 6 riquette (welding), and 20 reheating furnaces, with 10 rolling mills and 7 steam hammers of from 1 to 17 tons. The production of the puddling works was, in 1872, 12,550 tons, of which about 4,600 tons were steel (Bessemer) articles. The second works of this company, where wrought-iron articles are manufactured, are those at Steyerdor-Anina with a total area of 35,000 acres belonging to them. The production of wrought-iron articles in these works was 11,500 tons in 1872. The iron manufactured at the company's works is of a very good quality, though part of it is made of coke iron, the adjoining coalfields yielding good coking coal for the blast furnaces.

Before leaving the exhibits of Austria, we have to notice a most interesting and most valuable mode of forging wrought-iron articles of every description, and even the most complex forms met with in practice. We mean the system of forging in dies with a powerful hydraulic press. Mr. John Haswell, the manager of the locomotive works of the States Railway, was the first to introduce the forge press instead of steam hammers, for producing complicated forgings, and in 1862 drawings of Mr. Haswell's press were exhibited in the London International Exhibition. The press itself has since then been materially improved, and the forgings produced by this powerful machine are worth close inspection on account of the perfect homogeneity of the articles manufactured, the cleanness of the forms, and the apparent ease with which the material has been forced into the most intricate moulds. The forged articles, after leaving the mould, only require very little work upon them to be finished. Locomotive crossheads, axleboxes, &c. were exhibited forged by this process; but we understand that Mr. Haswell also forges the large locomotive axles and other heavier articles by means of the hydraulic press. We need not say that the whole process is a very economical one, and that the saving in labour, time, and material rapidly pays the outlay for the plant. Mr. Haswell exhibited some of these articles cut through, these having had the sections polished, and being etched to show the flow of the metal during the operation. This is another illustration of Mr. Tresca's theory of the flow of solids.

Though at first sight the whole process of forging with a hydraulic press seems to be a very simple and easy matter, experience has proved that this is not the case under all circumstances, and that it requires very clever management to develop all its advantages. Mr. Haswell made a forge press some considerable time since, for the works of Mr. Mayer, at Leoben, Styria, but after having vainly tried to arrive to the desired results, the proprietor sold this press to Mr. Schwarzkopff, of Berlin, who has produced excellent work with it. Another press on Mr. Haswell's system is in use at the large loco-

motive works of Mr. Borsig, at Berlin, where it works admirably. Mr. Borsig exhibited beautiful forgings similar to those of Mr. Haswell, and made by this gentleman's patent forge press. Further particulars concerning Mr. Haswell's system of hydraulic forging will be found in the section of this report dealing with locomotives.*

With Austria we close the review of the exhibits of those countries in which the manufacture of welded iron materials (wrought iron and puddle steel) is almost exclusively based upon the use of charcoal pigs, and where coke iron is only manufactured on a very limited scale.

We now come to the iron exhibits of Germany, Belgium, England, and France, where coke iron manufacture has been carried as nearly as possible to perfection, and where the results obtained in the conversion of coke pig iron into marketable wrought-iron or puddled steel have especially characterised the great progress which has been obtained during late years in the iron industry.

Our review leads us accordingly to those examples of welded iron material which, owing to the use of inferior coal or to the poorer quality of the ores, do not in general equal the iron products of Sweden, Russia, or even Austria (except Bohemia and Silesia) with respect to the purity, tenacity, weldability, and strength of the material, though in some districts of which we have now to treat, excellent welded iron is produced.

In consequence of this somewhat inferior average quality of the exhibited articles of Germany, France, Belgium, and England, we may expect to find the general texture of the wrought-iron articles of these countries of a more or less fibrous character, and, indeed, as well in the German pavilions for Group I. as in the French and Belgian machinery departments, where the articles of this group were exhibited, we found ourselves in the region of fibrous, and with reference to some Belgian iron samples we may even say ragged, wrought-iron materials. But though on first inspection the cohesion of the iron particles, as shown in the fractures of most of the exposed samples, did not seem to indicate a correct mode of manufacture, and though a visitor after having inspected the Swedish department might easily enough be inclined to take this fibrous structure as the sign of a want of care in the treatment of the puddled balls, yet we know that, as we have stated in our introductory remarks respecting the exhibition of welded iron materials, the fibrous texture of wrought-iron may become a necessity when the raw materials do not allow of the manufacture of pure granular iron. Therefore in such localities as in Belgium, where the ores found are not pure enough for the manufacture of dense granular iron, we must look upon the appearance of the fibrous samples, as an unsought for and disagreeable, but at the same time unchangeable and necessary quality.

On the other hand, when we meet with a tendency to transform a really good and pure iron into a fibrous mixture of cinder and metal, only for the sake of an old prejudice, we must condemn such unreasonable proceedings, some proofs of which we find in the French and German departments. But it may be hoped that even these exceptions to the rule will in a very short period give way to a better understanding of the interests of both the manufacturers and buyers.

In the German department we found a very good collection of rails, bar iron, plates, &c., amongst which the products of the Königs- and Laura-Hütte, the Borsig Works (in Upper Silesia), and the Burbacher Hütte (Saarbrüchen district), deserve special notice.

The Königs- and Laura-Hütte manufactured in 1872 about 92,000 tons of pig iron, 60,000 tons of castings, and 70,000 tons of wrought iron. The Borsig Works, belonging to Mr. Borsig, the well known locomotive manufacturer of Berlin, were erected in 1863, and consist of four blast furnaces, forty puddling, and twenty-seven welding and reheating furnaces, besides three Siemens-Martin steel furnaces. The works produced in 1872, 20,000 tons of pigs, and 1,300 tons of castings for its own use, and 15,000 tons of rolled bar iron for the German market.

The Burbach works produce annually about 20,000 tons of girder iron of different sections. A girder iron of a Z-section exhibited by this works was

* See Locomotives.

Burbach is shown in figs. 15 to 20 Pl. XXXIV. The interior of the pile is built up entirely of fibrous mill bars of 19 millimetres (0·748 in.) thickness, and for the top and bottom flanges, double welded plate iron 20 mm. (0·787 in.) thick is used. Fig. 15 shows the mode of piling for an I-iron of 176 mm. (6·93 in.) in height; for smaller sections the plates Q Q Q Q are generally omitted. Fig. 16 shows the mode of piling for I-irons where extra strength is required. Figs. 17, 18, and 19 represent the piling of different smaller sections.

In general the iron manufacture in the German department showed a decided progress since 1867, and it may be hoped that the depression of the iron industry in Westphalia by the incorporation of Elsass and Lothringen, where the cheapest iron in Germany can be made, will gradually subside.

In France we met with a very great extension of a speciality represented for the first time by M. Arbel, in 1867. We allude to stamped wrought-iron locomotive and railway carriage wheels. Many patents have been taken out for the manufacture of forged wheels since the Paris Exhibition, and nearly all the larger iron works of France are now making such wheels. We need only mention: MM. Brunon frères, Rive de Gier; Lucien Arbel, Desflassieux; and the Fonderies, Forges, et Acieries de St. Etienne. All these works exhibited at Vienna very good wrought-iron forged wheels according to different patents. The last-named works exhibited also the largest wrought-iron plates in the Exhibition; we herewith give their dimensions:—

	No.	Length. ft.	in.	Breadth. ft.	in.	Thickness. in.	Approximate weight. tons.
Rectangular plate	1	27	10½	7	10½	0·63	2½
„ „	2	48	7	4	2	1·23	4½
„ „	3	52	6	5	3	0·63	3
Circular plate	4	8	6½	diameter		0·63	0⅝

A beautiful wrought-iron forging—a locomotive double crank for outside gear—was exhibited by the iron and steel works of Firming, near St. Etienne, while there were also shown the well-known master-pieces of forging by the Creusôt works. These latter—toys rather than earnest products of human skill and labour, it seems to us—are exhibits not in accordance with the magnitude, fame, and power of production of the exhibitors' works; and this opinion is strengthened when we notice that the most complicated, elaborate, and skilful forgings shown at the Creusôt stand, by no means indicated the good quality of the materials used; but on the contrary, we may be convinced that all these fanciful objects are more or less be made of a very fibrous but impure material, which will only support the treatment of the most clever, most delicate, and unenergetic of anvilmen.

Belgium showed little of interest in connexion with wrought iron manufacture, unless we choose to take an interest in the very inferior quality of most of the exhibited articles, of which again the plates and rolled materials of the Forges de Clabecq, at Brussels, were the worst. This iron, in fact, is so bad, and has so little welding power, that it does not even show proper fibres, and the fibrous texture resulting from the impurity of the iron does not offer the slightest impediment to the breakage of the single fibres in planes at right angles to the surface of the bar, so that the break is a short one, notwithstanding the ragged and blotting-paper like appearance of the severed parts.

America and England exhibited very few objects of wrought-iron. Amongst those of the first-named country we must notice the cold-rolled shafting described in another part of these Reports,* and of the latter we have to record the results obtained by Messrs. Daniel Bateman and Sons, with 1 lb. of wire rod 7 mm. (0·275 in.) thick and 8 ft. long, by drawing it out to a wire 2½ miles in length. The fineness of the latter may be imagined. We mention this case here because it again is an excellent illustration of the principle enunciated by us at different parts of our record, viz., that a really good welded iron must be granular. The puddle bars shown by Messrs. Bateman and Sons, out of which the wire rods for the manufacture of the finest wire are rolled, have absolutely the same appearance as those of the Swedish department; they show a close, dense, equal, granular structure, proving an

* See Machine Tools.

excellent, pure, and easily weldable iron; fibrous iron could stand no such severe a test as that shown by the above-named firm.

Here we close our review of the welded iron exhibits, which leaves but little space to record the progress of the cast or homogeneous iron manufacture as shown by the exhibits of the different countries at Vienna.

Steel.

The vast importance of the steel manufacture is now universally allowed by all who have to deal with large quantities of iron for the purposes of bridge construction, railway works, or the manufacture of locomotives, engines, and tools, &c. It is true that many shades of opinion are still held as to the applicability of steel to various structural purposes, and while its many excellent qualities, such as its homogeneity and great strength when properly manufactured, have gained for it numerous enthusiastic admirers, there are still other engineers who strongly oppose its employment for such purposes. To a great extent this latter feeling is due to the conservatism which forms such a strong feature in the practice of certain cliques; but it has undoubtedly also been brought about in some cases by the experience of failures ensuing from an improper use of steel, or rather from the use for certain purposes of steel of a kind unfit for these purposes. But notwithstanding the open hostilities of some conservative parties and the over-zealous friendship evinced by other factions, the sterling value of the "homogeneous iron" has steadily and irresistibly enforced itself upon the minds of all unprejudiced engineers, and we now-a-days may even anticipate the possibility of this material superseding entirely, at some future time, the less compact and frequently less reliable welded material, generally called wrought iron.

This latter supposition is not without foundation, but to keep our impartiality unimpaired by the imposing rapidity of progress in the manufacture and use of steel, it will be well to trace some of the leading events which have aided the rapid adoption of a material, the manufacture of which, on a large scale, is comparatively of so recent a date, and the experimental results derived from which, still lack much of the uniformity so greatly to be desired.

The wrought-iron manufacture (which up to the last fifteen years represented the sole mode of producing large quantities of malleable iron material) has, there is no question, made no progress as to the quality of the products, but, on the contrary, a very sensible deterioration has been noticed in the general average quality of wrought-iron articles during the last twenty years.

We wish it to be well understood, however, that this remark refers only to the quality in general, and we admit with pleasure the fact, that many iron works may be found, where material of the highest class is manufactured up to the present moment. Moreover, we wish to call the attention of our readers to the fact that this deterioration in the average quality of wrought-iron products must not be looked upon as a cause for regret, but rather as one of those unalterable consequences of which we encounter so many instances in the history of industrial progress. The quality of wrought-iron products has been affected by so many and such powerful influences, over which the iron-masters have had no control, and by the successive changes in the whole character of the iron industry, that many of these influences have escaped the notice of most iron-masters themselves, and they would not entertain a moment's doubt as to the correctness of this statement if they were to review the progress, changes, and details of the iron manufacture within the period above named.

The principal movements which have produced these great changes have been the constant increase in the quantities produced per year; the constant decrease in the quantity of charcoal available for the iron manufacture; and lastly, but by no means least, the increased facilities of communication, and in consequence of this the increased competition and reduction of prices.

We do not think it necessary to prove that the increasing demand has led to an equivalent increase in the production—an increase which has, in a vast number of cases, rendered it impossible for manufacturers to confine themselves to the employment of only those classes of materials and conditions of working necessary for the manufacture of a high class iron. As the demand has not yet decreased, but, on the contrary, has reached unforeseen dimensions,

these influences have evidently not been diminished, and thus we now-a-days meet with enormous quantities of manufactured iron which, from what we have said, cannot possibly be of the same average quality as that produced some 20 years ago.

The deterioration in the quality of wrought iron coincides as nearly as possible with the manufacture of cast steel on a large scale, and we may say that with the increased production of "homogeneous iron"—as steel may properly be called—the quality of the welded iron material has diminished. This is a point of the utmost importance, as it will materially help to explain some seeming anomalies in the progress of the iron industry in general.

The valuable qualities of the homogeneous iron, commonly called cast steel, are now well known to engineers, and this knowledge, together with the well-established fact of the decrease in the qualities of the wrought-iron products, have aided to discredit the latter, and at the same time have given to the production of the former an impulse unprecedented in the history of human industries.

An example will show this to be the case. When railways were commenced nobody thought of using anything else but wrought iron for locomotive boilers, as the manufacture of steel in any suitable form could, at that time, prove no practical success. The quality of the wrought-iron plates used was excellent, as the quantities of such products then required being small, high-class ores and fuel were alone used in their manufacture. But, alas! these happy conditions soon began to be jeopardised by the rapid extension of the railway lines in all parts of Europe, and it could not be wondered at, that by the large demand for iron for railway purposes in general, the quality of locomotive boiler plates was affected, and, as it is well known, not in an agreeable sense of the word. But this deterioration of the quality was not found out for some time, as the change was an imperceptible one, and, in general, means of comparison were not at hand, or were not sought for.

This state of affairs suddenly changed, when in the beginning of the second half of the present century the manufacture of cast steel in the form of crucible steel, and later in the form of Bessemer steel, had made such progress as to enable the locomotive engineers to try and judge the unrivalled quality of the new material. It was at once discovered that the wrought-iron boilers then being used were more or less dangerous, that the quality of the plates was far from being satisfactory, and it was at once remembered that the oldest plates were by far the best of the lot, as far as the quality of the material goes. The ensuing consequences remind one of an every-day-life experience, namely, that you may endure any amount of nuisance as long as it is steadily but slowly increasing, but the moment one of your friends ridicules you about your patience, or you are in some way reminded of the possibility of a change, you will at once feel that your position has become intolerable, and you will rid yourself of the constraining conditions with a vehemence you would laugh at if you were a bystander.

A similar proceeding took place with regard to the adoption of steel plates for boilers, and we could state many cases where, indeed, the wish to get rid of wrought-iron boiler plates was, to a great extent, the inducement to introduce steel as a substitute before the specific qualities of this material were sufficiently known to entitle it to adoption on a large scale.

This fact also accounts for the diversity of opinions still existing as to the practicability of substituting steel for purposes for which iron has always been used, and often the most energetic and unrelenting partisans of steel at any price did more harm than good to the permanent introduction of this material, by inducing many people to employ steel, who had not the slightest notion of what could be expected from this new form of homogeneous metal, or of how it should be treated to develop its specific properties.

There is no doubt, if it were not for the absolute want of a homogeneous material stronger than wrought iron in two very different branches of human industry, we should not have had many noteworthy steel products to look after at the Vienna Exhibition. It is, indeed a very interesting fact that again an old proverb is right in saying that whatever may be done by man, some good will come out of it, even if the intention of the deed be the

contrary of the result. War certainly has not a favourable aspect from a philanthropic point of view; but, nevertheless, many a great invention has resulted from our earnest and unrelenting search after some new and more efficient means of destruction. We may, in fact, boldly say that, to a great extent, we are indebted for the present perfection of the steel manufacture to the progress of, and the assiduity in improving, our modern artillery.

Next to the influence of the desire for more perfect implements of destruction in improving the quality of the product, we owe to the development of railway lines the growth of the manufacture of large quantities of homogeneous material of an average quality.

From these two points of view it is easy to point out those works which are manufacturing steel of perfect quality, and where we shall find the manufacture of large quantities. We may say that with few exceptions all those works which, according to the quality of the raw materials used, are able to manufacture the very best description of cast steel, either have been or are employed in the production of weapons or guns of some form, whereas in those cases where the quality of the products does not allow of the use of the material for purposes of destruction more peaceful works are carried on, such as the manufacture of rails, axles, tyres, &c. Of course we do not mean to say that these latter products are excluded from the former class of works, but we merely assert that, speaking broadly, the relative proportions of the hostile or peaceful products of a steel works give a criterion of the average quality of the material. Thus we found among the manufacturers of the very best sort of steel at the Vienna Exhibition, Thomas Firth and Sons exhibiting steel blocks for guns of different calibre; the Aciéries et Forges de Firminy showing among other products steel for gun barrels; the Bochumer Verein displaying a variety of field and siege guns; Friedrich Krupp, of Essen, exhibiting the famous show of ordnance of the different calibres from the light field gun up to the heaviest coast defence, already described by us in another section *—the Russian show was analogous to that of Krupp—and the Fagersta Steel Works, Sweden, exhibiting gun barrels and heavy ordnance; while in Austria, we found in the pavilion of the Innerberger Hauptgewerkschaft, a trial gun from their works in Styria, and in the Carinthian and Styrian pavilion similar products, and so on.

On the other hand, we saw that those works which cannot—or for commercial reasons do not care to—compete with those above mentioned in regard to the quality of the material, and which in general, therefore, are bound to follow the system of large production with moderate prices, exhibited show pieces consisting of different railway articles. Thus John Brown and Co. and Cammell and Co. exhibited, beside their large armour plates, principally axles, tyres, &c., for railway rolling stock, while the French works: the Fonderies et Forges de Terre Noire; Schneider and Co., Creusôt; Marels frères, &c., also showed the same class of products. All Belgian manufacturers were also to be noticed under this head, and a good many of the German as well as some of the Austrian steel works.

* See Ordnance.

CIVIL ENGINEERING.

The exhibits relating to Civil Engineering at the Vienna Exhibition, apart from those of signals, permanent way, &c., were for the most part contained in drawings, models, photographs, and descriptions which, though not striking in appearance, were invaluable for reference and study. It is impossible to notice in detail the works to which such exhibits as those just mentioned referred, but we may give prominence to the principal ones, commencing with the admirably executed model of the Sone Canal Works. These models unfortunately were never put together perfectly.

The series of works which they illustrated are known in India under the name of the "Sone Canal Project."

The River Sone rises in the plateau of Central India, and, flowing in a northerly and north-easterly direction through the Kymore Hills for a distance of 230 miles, it enters the plains of Behar at the ancient fortress of Rhotas, and from thence runs in a straight course for 100 miles to its confluence with the Ganges near the city of Patna.

The channel of the river varies from 2 to 2½ miles in breadth, and discharges, in seasons of high floods, over a million cubic feet of water per second, and in its lowest season about 4,000 cubic feet as an average; while its "flood rise"—or the height above its summer level that it rises in high floods—varies in places from 14 to 20½ ft. These enormous volumes of water are discharged between banks generally higher than the surrounding country, which are supposed to have been formed by successive inundations and deposits of the floods. The bed of the river is composed of shingly sand to a great depth, and its fall varies from 3 to 1¾ ft. per mile. After entering the plains the Sone flows through the districts of Shahabad on its left bank and of Patna and Gya on its right bank. These provinces are amongst the most fertile and highly cultivated in Bengal, thickly planted, densely populated, and studded with ancient and wealthy cities. They produce wheat, rice, opium, barley, tobacco, Indian corn, indigo, sugar-cane, and cotton, &c. The staple article of food is rice, but the average rainfall is insufficient to insure a full yield of this crop, and the cultivators endeavour; by storing water at great expense and trouble, to supplement it artificially. In the unfortunately not unfrequent seasons of drought a great proportion of the food of the people is lost. The Government of India have, therefore, determined to utilise the waters of the Sone to irrigate these tracts, and the project sanctioned embraces several lines of navigation and the complete irrigation of an area of 5,100 square miles. It is estimated from experience derived from works of the same kind in other districts that the yield of rice alone will be doubled by seasonable artificial irrigation, while a much larger area can be placed under cultivation, and there will also probably be a very large increase in the produce of other crops.

The head of all the canals is at Dehree, a town situated 65 miles above the confluence of the Sone with the Ganges. At this place a weir is being thrown across the river in order to raise the level of the stream during the dry seasons. This weir or dam is already half completed, and will, when finished, be one of the largest works of the kind ever attempted; details of its design and construction will be given hereafter. Just above the dam the two main navigable and supply canals are taken off. That on the right bank is called the "Eastern Main Canal," and runs for a distance of 170 miles eastwards, crossing several smaller rivers by aqueducts, and passing under the East India Railway, falls into the Ganges, near the large city of Monghyr. This canal is 180 ft. broad at the base, and the depth of water will be 9 ft.; it is designed for the navigation of small steamers, and is intended to irrigate the whole area of country extending from itself northward to the right bank of the Ganges, an area of nearly 3,000 square miles. The volume of water which this canal is designed to carry is 5,300 cubic feet per second. The main navigable canal which is taken off from the left bank of the Sone at Dehree is called the "Main Western Canal," and runs along the foot of a range of

hills, a distance of 125 miles, to Mirzapore, on the Ganges. This canal is of the same dimensions as the Eastern Main Canal; it crosses several minor rivers by large aqueducts, and falls by several flights of locks a total distance of 123 ft. from the Sone to the Ganges. This line of canal carries sufficient water to irrigate the tract of country between the hills and the right bank of the Ganges, and is also intended for the navigation of steamers. It will thus be seen by a reference to the map, see Plate , that there will be a continuous navigable line of canal from Mirzapore on the Ganges to Monghyr, on the same river, a distance of 300 miles, passing through a populous and fertile country, and avoiding those portions of the Ganges which are the most difficult to navigate. The two main lines we have described are called the "High Level Canals," because they run on the highest ground it is possible to command, and therefore it is practicable to distribute the water from them all over the country to be irrigated. It will be seen from the map that branches run off from them towards the Ganges, some of these being navigable lines in connexion with irrigation, and some purely irrigation channels. Those which are intended to be navigable are marked in full lines, while the channels meant only to carry water for irrigation are marked in dotted lines. The total length of navigable lines to be constructed is 535 miles, estimated to cost, including supervision, about 4,000*l.* per mile. The total length of main distributaries for irrigation only, will be 1,050 miles, costing 500*l.* per mile. The total cost of the whole project will be about 4 millions sterling, and it is estimated all the works under construction at present are the weir across the Sone, and 180 miles of navigable canals on both banks of that river. The number of labourers employed in 1873 was at one time 40,000, and the expenditure was as high as 30,000*l.* per month. A double line of railway has been constructed 10 miles in length, worked by locomotives, to transport stone from large quarries in the hills to the site of the weir at Dehree. Large workshops and stores have been built at Dehree, where every kind of ironwork is turned out on the spot, and dwelling houses have been constructed at that place, and also on the different canal lines, for the accommodation of the numerous staff employed on the works.

Plate 246 contains, besides a map of the canals and feeders, a general plan of the head works of the canals. The latter shows the river at Dehree, the site of the weir, the sluices in it, the heads of the canals on either bank, the lock channels leading into them, the course of the main canals for a few miles, the station of Dehree, the residences of the Government employés on these works, the workshops and stores, the quarries, and the railway from them to the river bed. An enlarged plan of the weir and junction of the canals and river is also given.

All the works of which we have been speaking are under the superintendence of Mr. H. C. Levinge, by whom they were designed, with 20 English engineers under him, assisted by a staff of 100 subordinates.

We now proceed to give an account of the design and construction of the great weir (or annicut as these works are called in India), 2¾ miles in length, which is being built across the River Sone, at Dehree.

It may be advisable to say a few words as to the necessity and effect of a weir, built, like that under notice, to regulate the supply of water in canals which lead off from each flank of it on the upstream side. Canals have frequently been taken off from rivers without weirs, but where these rivers are liable to change their beds by erosion of their banks, or where they carry large quantities of silt in suspension, it has been found impossible to regulate both the river channel, and also the supply of water into canals on the banks, without a masonry work of this nature built right across the stream We will endeavour to show hereafter how a weir meets these requirements.

The minimum low water or summer level of the Sone at Dehree is 326 ft. above mean sea level. It is considered necessary to provide a minimum depth of 8 ft. over the lock sills, by which boats requiring to navigate the canals may enter them. And as it will, of course, be necessary to provide for this navigation in summer, when the river is at its lowest, it is evident that the summer level of the stream must be raised 8 ft., or to 334 ft. above mean sea. This will have to be done by a weir, the crest of which will be 334 ft. above

the sea, so that the water in the river will never fall below that level, and when there is more running in the river than is required in the canals the water will rise and fall over the crest of the weir. On each bank of the river immediately above the weir, there is a lock to admit boats, and head sluices to admit and regulate the supply entering the canals. In order to prevent the possibility of these locks and sluices becoming blocked up in front by shoals or bars, as might easily be the case in rivers carrying great quantities of sand and silt, under-sluices, as they are called, are provided at each end of the weir, close under either bank, which, when opened, form a gap in the weir wall, and passing through them large volumes of water at a high velocity, cause a considerable draught in front of the locks and sluices at the heads of the canals, and so carry away any shoals which may have been deposited there. The weir wall, which is 2½ miles in length, is again pierced in the centre of the river by another sluice, which is intended to provide against the formation by deposit of an island in the centre of the stream above the weir, for when these sluices are opened in the weir wall the draught through them will remove any sandbank in their vicinity. In the dry season when the canals take the whole supply of the river, the stream will stand level with the crest of the weir, and, as there is no silt brought down at that season, all the sluices in the weir will be closed, and the water will stand back above the weir, forming a lake several square miles in extent. In the rainy season, when the river is in flood, the stream rises 6⅓ ft. above the crest of the weir, and will fall over it down the paved slope in its rear and flow away, and at this season boats may easily navigate the river, passing up and down over the weir which, with the river in flood, affects the surface so little that its position can hardly be noticed, and that only by a long ripple. The sluices in the weir are made self acting, and the sluices at the head of the canal are worked by machinery. Thus it will be apparent how perfect a control the engineer will have over the regulation of the bed of the river, as well as the regulation of the supply to be admitted into the canals on either bank.

On Plate 246 is a section of the Sone weir or annicut. It will be seen that the weir consists of three parallel walls built 30 ft. apart, the height of the first being 8 ft. and of the others such, that the line joining their crests, slopes down from the main wall at the rate of 1 in 12. The walls are founded on wells (see view on Plate) sunk below the bed of the river to depths varying from 8 to 10 ft., and filled up with stone and concrete, the space between the walls being packed with rubble stone and the surface paved with large blocks, so that they will resist the violence of the stream passing over them in times of flood. The up-stream side of the main wall is also protected by packing at a slope of 3 to 1. All the walls are coped with ashlar blocks 2 ft. in depth, and the main wall is 5 ft., and the others 4 ft. in thickness. The works were commenced in 1869, and have been pushed on with vigour ever since. The first work required was to open the quarries, and the railway which carried the stone from them to the bed of the river, a distance of 10 miles. Some difficulty was found in carrying the line from the bank into the dry bed of the stream, as the bank being very high, an approach of 30 ft. in height was required, and as this approach was swept away each season when the floods came down, it had to be renewed each year, at great expense and delay. The dry-weather streams had also to be bridged to carry the railway, with wooden bridges supported on piles, and on the approach of the floods the beams and sleepers were removed and the piles allowed to stand until the next working season. It was however found that the channels taken by the dry-weather streams during one season would be quite different in the succeeding one, and from this cause much difficulty was experienced in diverting these streams in order to bring them under the bridges which had been erected.

The main wall was commenced by building the wells for its foundation, their curbs being laid at the level of low water. The great difficulty which presented itself at the outset was how to sink these wells expeditiously and economically. The works of this kind which have been constructed in Orissa and in Madras have been founded also on wells, but they were

excavated by hand by divers, and were sunk only 5 ft. or 6 ft. below low water. The wells in the Sone weir were designed to be sunk from 8 ft. to 10 ft. beneath lowest water, and, as it has actually happened, they are often sunk 12 ft. below; this extra depth is rendered necessary to provide against the great stress which the enormous body of water discharged by the Sone plunging over it with great velocity brings upon the apron of the weir. The old method of sinking wells by divers would have been extremely slow, and, therefore, if for no other reason, not economical; and it is doubtful whether at such depths as were required in this work, such a process would not have been very costly. There are several methods employed in India for sinking wells, the commonest among which is that by a jham or scoop, but this is also a very expensive and tedious process. The difficulty and delay of all these crude methods were unexpectedly removed by the invention by Mr. Fouracres, the executive engineer of the workshops at Dehree, of a very simple but highly ingenious and useful tool, which, with a minimum expenditure of labour, and with amazing celerity and accuracy, digs out the sand from any required depth under water, and delivers it at the mouth of the well faster than it can be carried away. An engraving of this implement, which is now being used in many of the largest works in India, is given on Plate 247, Figs. 1, 2. Its success has been most decided, and to give an idea of its utility we may mention that a hollow block or well 10 ft. by 6 ft., can be sunk 10 ft. into the sand in nine hours, and in one season the depth of blocks sunk on the Sone amounted, in the aggregate, during four months, to three miles of sinking through sand.

The method pursued is as follows: if the wells to be built are on a sand-bank in the river bed, which is dry, the sand is excavated until water is reached, the well curbs, made of bamboos, are placed on the level of the water, and the masonry of the well is commenced; but if a stream has to be crossed it is first dammed and the water stilled. This is, of course, often a very difficult operation where the bed of a river consists of sand to a depth of, perhaps 60 ft. After the water is stilled, sand is thrown in, and an embankment formed across it, sufficiently wide to found the wells on; they are then built on it and afterwards sunk. The wells are allowed to stand from 10 to 15 days after being built, to allow the masonry to set. The blocks are then sunk by excavating the sand from within them, it being generally found that the quantity of excavation is about double the cubic area of the block sunk. The blocks, under the weir walls, are 6 ft. wide, and are sunk in single rows under each wall, each well being separated from the adjacent one by a space of about 6 in. The inside of the blocks and the craters all round them, caused by the excavation of the sand, are then filled in with rubble stone, the surface, to a depth of 2 ft. inside and between the wells being filled with concrete. Large slabs are then placed over the top of the blocks, binding the walls to the hearting, and also bonding them to one another, and the masonry of the wall is then commenced. The number of these blocks which have been sunk already in the Sone is about 4,000.

The Fouracres' excavator (see fig. 1, Plate 247) consists of two jaws of the shape of the quadrant of a circle, which revolve on a horizontal shaft, which is itself suspended by a vertical spindle and chain to the scaffolding above the well to be sunk. Each of these jaws is connected by iron rods to a small wooden platform, which runs up and down on the spindle at the level of the top of the well. Two men standing and jumping on this platform, when the excavator is let down to the bottom of the well, force the jaws to close and bite up the sand from the bottom. The excavator is then hauled up to the top of the well, the jaws are opened by a lever, and the sand, falling out of them, is carried off on a shoot from one side of the well. Fig. 2 is the same tool adapted to sink wells to greater depths than 12 ft., or to any depth. Instead of the wooden platform and rods by which two men force the jaws of the tool together under water, this excavator has a chain fastened to each of its jaws, which is rove through blocks fixed under the curb of the well to be sunk. These chains are brought up to a platform on the top of the well, and wound up by winches placed there, so that the jaws of the excavator are closed and made to bite the sand by winding up these chains. Fig. 3 is the native

"jham" or scoop. It is driven into the sand under water by a long handle of bamboo, and then the mouth of the scoop, which revolves on the handle, is tilted up full of sand by a rope, and hauled up.

On Plate 248, Fig. 2, is an engraving from a photograph, of a row of blocks for the foundations of the weir wall of the Sone Annicut, being sunk with this excavator. Most of the blocks have disappeared out of sight, having been sunk, but a few are still above ground, and the view shows the scaffolding on which the pulleys are fixed for raising and lowering the excavator, and the manner in which the space is emptied out of the excavator on to a shoot at the side of the well, and then carried away. At the block, on the extreme right of the engraving, an excavator is shown just raised from the well, quite full, and about to be opened to deposit its sand on the shoot; and on the next block is an excavator quite open, which has just been emptied, and is about to be lowered again. It will be seen that six men are required to work this tool, two at a windlass, two to stand on the platform, and force the jaws together to bite the sand, one to open it when it comes up full, and one to draw away the sand when it is deposited on the shoot. On Plate 248, Fig. 1, is also given an engraving, showing the work in progress for the foundations of the under sluices in the weir. The flooring for each set of sluices (of which there are three in all in the weir), is 536 ft. long by 90 ft. wide. The original design contemplated putting in this platform 4 ft. thick of rubble masonry, paved with 9 in. thickness of cut stone, but it was found in practice impossible to pump out the water to the required depth to enable the masonry to be laid in, as the soil consisted entirely of loose sand and shingle, so that the plan was hit upon of putting in the foundations under water by means of wells or blocks sunk with Fouracres' excavator, and the engraving shows the area of the sluice platform covered with these wells or blocks ready to be sunk. They were built 3 ft. high on light bamboo curbs laid on the sand at water level, and when the masonry was set, were sunk until their tops were 1 ft. under water. Concrete was then thrown into and around them under water, and when this had firmly set, there was a solid floor established, through which water could not percolate, and no difficulty was then found in pumping out the water from above them, and laying in the masonry to the required height all over the platform. This is an extremely inexpensive and expeditious way of laying foundations in sand and water, where any other method would be very expensive and laborious. The ashlar paving, 15 in. thick in the sluice-ways and 9 in. on the apron, is then laid on, and the piers built on of cut stone, leaving 25 openings of 20 ft. clear, which are closed up with self-acting shutters, the working of which we shall describe hereafter. The sluice opening will be 500 ft. clear, and as there are three sets of sluices, there will be, when necessary, 1,500 ft. of sluice opening available; 20 ft. up stream of the sluice flooring a line of wells is sunk 10 ft. in depth, coped with ashlar as a curtain wall, and the intermediate space all along the face of the sluices is packed with large boulders as a protection against erosion. The down stream side also of the sluice flooring is provided with a curtain wall of blocks sunk 10 ft. in depth, close together and filled with concrete, and coped with ashlar. Above and below this wall is an apron 60 ft. in width, formed of large boulders tightly packed all along the rear of the waterway to protect the tail of the work from erosion. It is calculated that the velocity of the water through these sluices will exceed 12 miles an hour with a depth of 8 ft. to 12 ft. sometimes, when the gates are opened. It is intended to span the openings with a light iron foot-bridge, so as to allow of easy access to the gear which works the sluices. As has been already stated there are three sets of these under-sluices, one at each end of the weir wall under the river banks, and a third in the centre of the stream to prevent an island accumulating there.

We proceed to give a short description of the self-acting shutters invented by Mr. Fouracres, which are used to open or close the under sluices in the weir. We have already stated that there are three sets of sluices of twenty-five openings of 20 ft. in each set, and that only in times of flood, and in order to scour out any deposit which may be formed opposite the lock entrances on either bank, are they required to be opened. The usual practice

in works of this kind is to have small openings of 6 ft. in width, with a roadway overhead, the openings being closed or opened by gear from the top, but it was found that by thus diminishing the size of the passages, the efficiency of the scour was also considerably diminished, and, moreover, openings of that size were unable to pass through them all the large timber, wrack, and brushwood, which an Indian river brings down in times of high flood. It was therefore attempted, in Orissa, to increase considerably the size of the sluice openings in the weir in the Mahanuddy river, and shutters on the plan adopted by French engineers in the navigation of the Seine were constructed. This method consisted of two parallel rows of shutters hinged to a cast-iron girder along the sluice floor, the up-stream shutter fell up stream, and the down-stream shutter fell down streamwards, so that the up-stream shutter, unless intentionally fastened down, would, when the flood came down, be raised by the water getting under it and flowing against it, and would thus shut itself off, leaving the shutter below it quite dry. This shutter was supported up stream by chain ties. When it was necessary to open the sluice again, of course it would not have been possible to lower the upper shutter against the head of water standing against it, and therefore the lower shutter was raised and strutted up by hand (as men could easily walk about on the dry sluice channel), and this made a double row of shutters standing against the stream. The space between these was allowed to fill with water, and then the upper shutter, being in equilibrium, was allowed to fall back into its place on the bottom of the sluice, while the lower shutter supported the head of water. The lower shutter was then lowered by knocking away the feet of the struts which supported it on the down-stream side, and it then fell down streamwards and the sluice was open.

The objection to this plan was that the upper shutter was raised by the stream with such velocity and force that the chain ties supporting it frequently gave way, and the shutter was carried off its hinges. It was also necessary that the shutter should be self-acting, as to opening itself to let a flood pass through the sluices, and it was to meet these two requirements that Mr. Fouracres' self-acting shutters were invented. On Plate 247 will be found engravings of three views of these shutters in different positions, as well as two sections, which will further assist in explaining the arrangement.

The upper figure shows the sluice "all clear," with both shutters down lying on the floor, the floods being supposed to be running freely between the piers, which are 8 ft. in height. When it becomes necessary to close the sluice and shut off the water flowing through it, a clutch worked from a handle from the top of the pier is turned, which frees the shutter from the floor, and it then floats partially up from its own buoyancy, when the stream, impinging under it, raises it to an upright position with great force, shutting up the sluice way. But if a shutter 20 ft. long were allowed to come up with such pressure, it would either carry away the piers or be carried away itself. To destroy this shock, Mr. Fouracres has contrived six hydraulic buffers or rams, which also act as struts for the shutter when in an upright position. These rams are simply pipes with a long plunger inside (see enlarged section, Fig.); the pipes fill with water when the shutter is laying down, and when it commences to rise, the water has to be forced out of them by the plunger in descending, and, as only a small orifice is provided for the escape of the water, the ascent of the shutter forced up by the stream is slow and gentle, instead of being violent.

The water is now shut off effectually, as shown in the second figure on Plate 247; but without other means being taken, it would be impossible to open the sluice again, as it could not be forced up stream. Another shutter is therefore provided below it, as shown in this same view, and in the section, Fig. 8, Plate 247, this lower sluice being arranged so that it can be lifted up by hand and placed upright, as shown in Fig. 6 on Plate 247. The water is then allowed to fill the space between the two shutters, and the upper one can then be thrown down on to the floor again, but the lower one is held up by ties which are hinged to it at one-third of its height, and by this means it is "balanced," and resists the pressure on it until the water rises to its top

edge, when it loses its equilibrium and falls over, thus opening the sluice again. The sluices can be left to fall of themselves if the river rises in the night; or if it is not thought expedient to let them fall they can be made fast by a clutch on the pier head, as shown. By these expedients, these large sluice ways, 20 ft. broad and 8 ft. deep, can be shut off or opened as required, with the greatest facility and expedition, and the whole set of 25 sluices can be opened in a few minutes, and when opened they can pass through them anything that the river brings down without danger to the weir. It has been proposed to bridge over the piers with a light iron foot bridge to enable a man to work the clutches of the shutters more easily.

On Plate 249 is an engraving of the head sluices of the main canals. There are two sets of sluices of precisely similar design, one for the eastern and one for the western main canal. As has been already stated, these sluices are constructed to regulate the supply of water entering the canals from the river, whether the latter is in high flood or at lowest summer level. They are built on each bank of the river immediately above the abutments of the weir wall, and at right angles to it, and contain each 24 openings of 6 ft. The level of the sluice floors is the same as that of the plinth of the weir wall, or the summer level of the river, and the level of the springing of the arches over the sluice ways is 8 ft. above the floor, or the same height as the crest of the weir wall, so that the minimum depth of water entering the canals through these sluices must be 8 ft. In order to keep the canals in full supply, which is 4500 cubic feet per second, the velocity through these sluices will not require to be more than 4 ft. per second. They are worked by gates raised and lowered by screws from the parapet above. When the flood in the river rises above the weir wall, and consequently above the top of these sluice ways, some of the openings will be closed down, so that the quantity entering the canal may not exceed what is required. Fig. 1, Plate 249, is a half elevation and half section of the head sluices. They are built on a platform 102 ft. broad and over 300 ft. in length, which is founded on stiff clay and composed of masonry 2 ft. 9 in. in thickness, and paved over with 15 in. of ashlar. The piers, of cut stone 4 ft. in thickness and 27 ft. long, are built on this platform and spanned with semi-circular brick arches. Above these arches rise parapet walls 11 ft. in height, Fig. 3, so as to bring the roadway over the sluices above the flood level of the river. The space between the parapet walls up to the roadway is packed with clay well rammed. Curtain walls, 4 ft. in depth below the flooring (and 10 ft. in depth where sand is found), are sunk above and below the platform, and an apron of stone packing 30 ft. wide protects their whole length both on the river and canal sides. These sluices also answer the purposes of a bridge, as the roadway over them is 13 ft. in width.

Figs. 6, 7, 8, Plate 249, show the head locks by which boats will enter the Sone Canals from the river. In the season of low water the lock gates will be open, and the river water, held up by the weir, will be on the same level as the canal, but, when the floods rise in the river, boats will have to be dropped into the canals through the locks. The lock-chambers will be each 120 ft. by 20 ft. with 8 ft. of water, and are designed to pass small steamers through them.

Fig. 10, Plate 247, is a plan of the foundations showing the blocks as sunk under the chamber walls and sill walls, and also under the wing and curtain walls. It will be seen that these blocks are sunk 11 ft. below the surface of the chamber flooring. They were sunk in a sand foundation, and were built on the level at which water first appeared in the foundation pit, and then sunk through the sand and water till the tops of them were on the level of the chamber floor. They were then all filled with concrete under water, and the interstices between each block also filled up with concrete, and then the four spaces, into which the lock-chamber is divided by the blocks, were excavated by Fouracres' excavator under water to the required depth, the blocks forming a wall round each area, and preventing the sand outside from slipping in, and the whole area was concreted over to a depth of 4 ft. After the floor had in this way been made water-tight, there was no difficulty found in pumping out the water standing above it,

and the chamber walls were founded on slabs placed over the tops of the wells. This was found to be a very satisfactory and inexpensive method of laying in foundations in a porous soil, which by any other method would have entailed considerable expenditure in unwatering the pit. The chamber walls are 19 ft. in height, and when the river is full in time of flood it is expected it will rise to a height of 8 or 9 ft. above the lowest water level making a depth of water in the lock of 16 to 17 ft., which leaves a margin in the height of chamber walls of 2 ft. above highest water level. The highest drop from the lock into the canal would therefore be 9 ft. in highest floods. The floor of the chamber is paved with ashlar 12 in. in thickness. A foot bridge, 10 ft. in width is provided over the tail bay of the lock. Both the entrance to and exit from the lock is paved with loose stone to a distance of 30 ft. The quoins, sills, and coping are laid with blocks of ashlar.

This description of the works on the Sone Canals may be concluded with a short account of a syphon aqueduct erected over the Kas River on the ninth mile of the Western Main Canal, and of which we give an engraving, Figs. 12, 13, Plate 247. The canal at this place crosses a stream which overflows its banks in floods, and the surface of the water in the canal is on the same level as the surface of the stream is in its floods, so that a great difficulty arises as to how the river water is to be passed across the canal. The expedient which has been adopted is to sink the openings of the aqueduct which carries the canal across the river below the river bed, and the stream is made to fall into a well below its own bed, pass under the canal, and rise again on the opposite side to its natural level, thus forming a syphon passage. In this case the river surface in flood is 10 ft. in height above the crown of the openings, so that there is an upward pressure, tending to blow up the crown of the openings, of about 620 lb. on the square foot, and the difficulty is to construct the syphon so that it will resist this upward strain when the weight of the water in the canal may be, for any reason, taken off the aqueduct. The openings are 24 in number, and are 6 ft. square by 100 ft. in length. There is a drop wall provided at the entrance to the syphon, and a well, 18 ft. in breadth, extending along the entire length of the syphon, into which the river drops.

The flooring is 3 ft. in thickness, covered with 15 in. of ashlar paving, and the piers are of cut stone, covered over with slabs, or covering stones, 8½ ft. in length, and 1½ ft. to 2 ft. in thickness. These covering stones are toothed into each other, and are bolted down through the piers by 1 in. iron bolts, so that they may resist the pressure of the water trying to lift them from underneath. One foot thick of concrete is then spread over the covering stones for the canal bottom. A reference to the plans will explain this construction more fully.

In conclusion is appended a general abstract of the estimated cost of the Sone Canal project.

GENERAL ABSTRACT of the ESTIMATE of COST of WORKS.

		£	s.	d.	£	£
295	Miles of high level, at per mile.	4,000	0	0	1,180,000	1,180,000
240	Miles of main irrigation and navigation canals, at per mile.	3,000	0	0	720,000	720,000
	DISTRIBUTION.					
928	Miles of main irrigation distributaries, at per mile.	500	0	0	464,000	
261,000	Acres irrigated in detail, at per acre.	2	0	0	522,000	
						986,000
26,250	Acres minor drainage works, at per acre.	0	8	0	130,500	130,500

Cost of head works, as estimated in detail.	—	£ 225,000	£ 225,000
Workshops, bungalows, at head works, &c., as estimated in detail.	—	43,000	43,000
			3,284,500
Superintendence, at 12½ per cent.	—	—	410,500
			3,695,000
Add for plant and tools -	—	—	80,000
Total - -	- - -	- -	3,775,000

The United States of America.

The United States of America contributed very little to the Civil Engineering group at the Vienna Exhibition. We may however mention the submarine operations now in progress for clearing the harbour of New York, and of which drawings and descriptions were sent. These works have for many years been steadily pursued to remove the sunken rocks which impede dangerously the navigation; much money has been expended, and many of the obstructions have been removed, one of the most important, known as the Hell Gate, has been worked for more than two years, and various means have been tried in vain to remove it. At last, a system similar to that carried out in San Francisco harbour with the Blossom Rock was adopted, and regular headings are being driven with the eventual purpose of moving the mass bodily by a gigantic blast. The work has made steady though slow, progress as the rock penetrated is principally gneiss streaked with veins of quartz, and is extremely hard to drill. The work now in progress at Hallett's Point contemplates the removal of the whole of the point or reef which obstructs navigation, leaving a channel of ample depth for the largest vessels with a vertical shore of rock on the land side. To effect this object, a vertical shaft has been sunk within a coffer-dam, one side of the shaft corresponding to a portion of the proposed shore line. From this shaft radiate ten headings as shown in Fig. 2, Plate 250, and which have been driven of various lengths from 34 ft. to 89 ft; the first and tenth headings following the proposed shore line. The headings are crossed by galleries, and the piers left standing are penetrated by chambers, having a ground plan of the form of the letter T. In these chambers the final charges will be placed and fired, when it is expected the entire mass of rock, left standing after the cuttings, will be broken in pieces of such a size that they can easily be lifted and removed.

The principal portion, in fact, practically the whole of the work, has been done by Cornish miners, imported for the purpose, and with hand drills. Figs. 1, 2, Plate 250, give an idea of the way in which the works are carried out, and of Severance and Holt's drills employed in boring.

Some inconvenience was met with during the progress of the work, arising from the inflow of water through fissures. The methods employed for closing such fissures are of interest. When the fissure is vertical, holes are drilled along each side of it, at a little distance from its margin. The holes are charged with slow powder, which is simultaneously discharged by an electric battery, the effect being to close the crack. When a horizontal fissure in the wall of a heading is met with, oak wedges are driven into the seams of the strata underlying it, which close it. Other leaks are stopped by means of oakum and cement. What little water flows in from small crevices is drained into a well at the foot of the shaft, and removed by a pump.

The diagrams show the shaft and the headings radiating therefrom, together with the concentric galleries, and the T-shaped chambers, which will ultimately be cut in all the piers. The tunnel headings average 20 ft. in height by 13 ft. in width. The concentric galleries average 16 ft. in height by 10 ft. in width. The shaft is 105 ft. in length by 105 ft. in width, and is sunk to a depth of 32 ft. below mean low-water mark.

We may also mention in connexion with the United States exhibits some photographs of a bridge recently erected by Messrs. Joseph M. Wilson, and Henry Pettit. The structure is illustrated in Plates 250 and 251. It carries the Pennsylvania Railroad across the Monongahela river, at Pittsburgh, by a bridge of 11 spans, exclusive of the approaches, amounting to a total length of 1,622 ft. When first erected, the superstructure was constructed of timber, with the exception of the channel span, 260 ft. long, which was built of iron on the Linville and Piper plan of truss. The cast span has lately been replaced by an iron structure, designed upon the triangular system of H. Pettit, on which system a number of bridges have already been erected on the line of this road, and proved to be very satisfactory. This new span is a double track deck bridge of two trusses, constructed entirely of wrought iron, except the rollers and blocks under the hinged bolsters, which are of chilled castings, and a few bolts that are of steel, the different members being joined together by pin connexions throughout.

The following are the principal dimensions:

	ft.	in.
Length of span, centre to centre of end pins - - - -	182	0
Number of trusses in span - - - - - -	2	
„ main panels in each truss - - -	6	
„ sub „ „ - - -	12	
Length of main „ „ - - - -	30	4
Distance centre to centre of trusses - - - -	19	0
Height of truss, centre to centre of chord pins - - -	22	10
Height from top of masonry on bridge seat to base of rail -	4	11

The ultimate strain per square inch for tension is taken at 60,000 lb., and for compression in the case of short prisms, 36,000 lb., a factor of safety of 6 being adopted throughout the structure. The upper chord is formed of channel bars, connected together at the top by a rolled plate rivetted on; and the section of chord is increased towards the centre by thickening plates on the webs of the channels, and also by rolled plates on the top of chord, the whole being thoroughly rivetted together, forming a continuous piece the full length of the bridge. The main diagonals and lever chords are composed of links 9 in. deep, and of varying width, having upset heads at the ends drilled for connecting pins. The main diagonals in the panels next to centre of truss are braced by internal diagonal bracing, so as to resist compression under variable loads.

The strut ties and stiffeners forming the secondary system, are made of channel bars, and rolled links; the latter being stiffened by ferrules, and rivets. The vertical posts are made of I beams, stiffened by plates, rivetted to the flanges, flat bars, ferrules and rivets. The first post forming the ends of the truss is stiffened, as shown in the drawings. Upper lateral bracing is put in at every sub-panel, and lower lateral bracing at every main panel; the lower bracing being connected at one end with the upper chord connecting pins. Diagonal bracing is put in at every main post, and at the sub-posts of the two centre panels. All the parts of the trusses are held together at their intersections in both upper and lower chords, and also at the centre of length of the main diagonals by rolled wrought-iron connecting pins, 5 in. in diameter. The floor beams are of wrought-iron channel bars connected by a top plate and trussed. The track stringers are of white oak The bolster blocks and pier plates are the "Wilson patent" of wrought iron, and having hinge connexions with the trusses.

Thickening washers are used on all connecting pins whenever necessary to make the joints snug and tight.

FRANCE.

The exhibits made by France, which may be included in this section, were remarkably rich and varied. They consisted of models, drawings, photographs, and documents. The former were very numerous, and of beautiful execution, and besides being of interest to the general visitor, they were of themselves instructive in a high degree to the students. The same remark equally applies to the other points. But nevertheless the whole of these exhibits was but as the atlas of some of the greatest and most modern works of the Ponts et Chaussées, to which the text was wanting. This text has been supplied, however, in a volume issued by the Ministry of Public Works, and a second by M. Felix Lucas, Ingénieur des Ponts et Chaussées. To pass by these exhibits without a somewhat detailed notice would render this section lamentably imperfect, and we propose to do so, with the assistance of the volumes just referred to.

The first exhibit to be mentioned is the great map of France, showing the various lines of communication throughout the country, as well as ports and lighthouses, and which are classified into, 1, roads and bridges; 2, railways; 3, internal channels of navigation; 4, sea ports; and, 5, lighthouses and buoys.

1. *Roads and Bridges.*—These are divided into (*a*), the grand routes, including national roads and those of the departments; and, (*b*), auxiliary roads, comprising highways and ordinary roads.

The first of these which, before the railway epoch, formed the great means of communication, are under the charge of the Minister of Public Works, and they are formed, maintained, and guarded by the State. The departmental roads are, for the most part, made and maintained by the service of the Ponts et Chaussées at the expense of the departments. The construction and maintenance of the subsidiary system is given in each department to some efficient person selected by the prefect. In 1870, the latest date available for complete data, there were in France 54,000 miles of first-class, and 168,000 miles of second-class roads.

In the same year the number of roads classified was 233, and their total length was 24,100 miles. The national roads are covered with stones with or without formation for the greater part of their length. The length of the paved roads through towns may be estimated at 1,620 miles. The normal thickness of the stone on the surface ranges from six to eight inches.

The average width of the national roads is 52 ft. 6½ in. made up as follows:—

Roadway - - - - -	19 ft. 8⅓ in.
Side walks - - - - -	19 „ 8½ „
Ditches and slopes - - - -	13 „ 1½ „
	52 ft. 6½ „

The expense of maintenance averages about 38·4*l.* per mile per annum.

The departmental roads classified in 1870 numbered 1,749, with a total length of 29,750 miles. The total width of these roads, including ditches and slopes is 39 ft. 4½ in. The cost of construction of these roads averaged about 1,190*l.* per mile, and the annual cost of maintenance 29*l.* per mile.

The highways have an average width of 32 ft. 10 in., including ditches and slopes, and their cost of maintenance averages 19*l.* per mile. The smaller roads are 26 ft. 3 in., and 23 ft. wide.

2. *Railways.*—The railways of France are worked by companies under concessions granted by the State. There are six great companies; the Northern, the Eastern, the Western, the Orleans, the Paris-Lyon and Mediterranean, and the Southern. There are in addition a number of secondary systems and of isolated lines conceded to various companies.

The State rests proprietor of the ground, the earthworks, bridges, viaducts, &c., as well as stations, shops, rails, turntables, and fixed machines belonging to the railway; and it concedes the use of these to the companies, which have to keep all in perfect maintenance. The latter are sole proprietors of the rolling stock and movable plant, such as the tools in the shops, station furniture, &c.

On the 1st January 1870 the length of lines opened for traffic was 10,600 miles, of which 4,900 miles were double, and 5,700 miles were single way. The area of ground occupied by the lines was 115,300 acres, including stations; the average width taken being 99 ft. In most cases where only a single line has been laid the ground for a double line is preserved. The minimum radii of curves legislated for, varies from 328 feet to 1,640 feet, according to the nature of the line, and the steepest gradients from 1 in 133 to 1 in 37. The rails are generally laid on cross sleepers, very rarely upon longitudinal ones. The length of rails employed varies from 10 ft. 6 in. to 22 feet, and their weight per yard from 50 lb. to 73 lb. Double headed and Vignoles' sections are chiefly employed. The space between the lines of rails varies from 5 ft. to 6 ft. 6 in. There are on the six lines before named 2,350 stations, and the number of aqueducts, culverts, and bridges less than 65 feet long is 29,351, having a total length of 40 miles. The collective length of the large bridges and viaducts is 70 miles, and the number is 1,113. Tunnels to the number of 480 have each an average length of 1,477 feet, the total length being over 130 miles. The following table shows the distribution of these works among the six great companies.

TABLE I.

Name of Railway.	Number of Road and Bridge Crossings.			Collective Lengths of			Numbers of Stations.
	Below Rails.	Level Crossings.	Above Rails.	Aqueducts and Bridges less than 20 ft.	Viaducts and Bridges above 20 ft.	Tunnels.	
				Yards.	Yards.	Yards.	
Northern - - -	594	1,005	314	5,924	6,052	6,904	196
Eastern - - -	755	2,183	475	10,358	19,541	28,947	392
Western - - -	1,112	1,131	730	8,822	13,755	31,535	287
Orleans - - -	1,716	2,558	880	13,301	28,569	46,839	486
Paris, Lyon, Mediterranean	2,749	2,641	931	22,193	40,115	99,071	651
Southern - - -	463	1,469	182	7,224	12,502	13,524	240
Totals for the six railways.	7,389	10,987	3,512	67,822	120,534	226,820	2,252
Other lines - -	138	665	55	1,985	1,922	2,542	98
Grand totals - -	7,527	11,652	3,567	69,807	122,456	229,362	2,350

Upon these lines there were 4,870 locomotives, of which 2,273 were for passenger, and 2,597 for freight traffic. The number of passenger carriages was 11,755, and may be classified as follows:—

1st class carriages, including special vehicles - -	2,449
2d " " " composites - -	3,972
3d " " - - - - - -	5,334

The accommodation averages in each of these vehicles, 25 seats for the first class, 42 for the second, and 44 for the third.

The baggage wagons numbered 4,575, their average capacity being 4½ tons. There were 117,616 freight wagons, having a mean carrying capacity of 8 tons. Amongst the vehicles in all, 24,850, about one-fifth of the total number is furnished with brakes.

Table II. shows the distribution of the rolling stock and engines.

TABLE II.—ROLLING STOCK ON FRENCH RAILWAYS, Jan. 1, 1870.

Name of Railway.	Number of Locomotives.		Passenger Carriages.	Number of Wagons.	
	Passenger.	Goods.		Vans.	Freight Wagons.
Northern - -	285	467	1,201	713	16,327
Eastern - -	429	471	2,387	737	20,149
Western - -	351	279	2,239	839	10,643
Orleans - -	418	317	2,083	658	14,407
Paris, Lyons, Mediterranean.	557	858	2,496	1,092	43,423
Southern - -	163	191	1,072	464	9,643
Totals for the six companies.	2,203	2,583	11,478	4,503	114,592
Other companies -	70	14	277	72	3,024
Totals -	2,273	2,597	11,755	4,575	117,616

The total expenditure that had been made up to the same date is shown in the following table, in which the outlay incurred by the state, the companies, and by the departments is given separately.

TABLE III.—COST OF CONSTRUCTION.

Names of Companies.	Total Length of the Lines to which the Expenses are applied.	Past and Future Expenses.			Average Cost per Mile.
		By the Companies.	By the States.	By the Departments, Communes, &c.	
	Miles.	£	£	£	£
Northern - { Old réseau	733·75	21,680,000	280,000	112,000	30,080·30
Northern - { New réseau	406·25	8,000,000	392,000	44,000	20,762·56
Eastern - { Old réseau	621·25	14,528,000	4,816,000	4,000	31,142·72
Eastern - { New réseau	1,316·87	34,884,000	2,812,000	276,000	28,832·80
Western - { Old réseau	562·5	20,484,000	4,064,000	140,000	43,886·08
Western - { New réseau	1,240·25	29,440,000	7,304,000	448,000	29,836·84
Orleans - { Old réseau	1,260·63	23,568,000	9,304,000	160,000	26,201·92
Orleans - { New réseau	1,438·75	33,348,000	4,702,000	44,000	26,581·64
Paris-Lyon-Mediterranean - { Old réseau	2,680·25	79,580,000	13,542,000	244,000	34,754·28
Paris-Lyon-Mediterranean - { New réseau	1,075·	24,096,000	5,736,000	4,000	27,735·98
Southern - { Old réseau	497·5	13,148,000	2,060,000	8,000	30,594·98
Southern - { New réseau	907·5	22,360,000	6,608,000	80,000	29,290·56
Total for the six great companies.	12,330·50	325,116,000	61,620,000	1,564,000	30,264·86
Different companies -	911·875	13,160,000	3,920,000	160,000	17,506·112
Grand totals - -	13,729·375	338,276,000	65,540,000	1,724,000	—
		£405,540,000			

Turning now to a brief consideration of the working of French railways, we find that during the year above mentioned there were 10,291 miles worked by the various companies, namely:—

By the six great companies	Old system -	5,848 miles.
	New system -	4,156 „
By the various other companies - - -		287 „
Total -		10,291 „

Table IV. gives the financial results of working for each of the great companies, for the Ceinture railway, and for all the others grouped together.

TABLE IV.—FINANCIAL RESULTS.

Names of Companies.	Mean Length.	Results of Working.			Gain per Mile.
		Receipts.	Expenses.	Difference.	
	Miles.	£	£	£	£
Northern - { Old réseau	666·25	3,452,200	1,443,880	2,008,320	3,014·4
Northern - { New réseau	262·50	405,200	227,200	178,000	678·08
Eastern - { Old réseau	610·625	2,401,440	1,098,160	1,293,280	2,281·728
Eastern - { New réseau	1,096·375	1,952,800	1,031,200	921,600	840·102
Western - { Old réseau	562·50	2,494,000	1,215,760	1,278,240	2,272·448
Western - { New réseau	795·	996,400	632,480	363,920	457·792
Orleans - { Old réseau	1,260·	3,682,240	1,485,000	2,197,240	1,742·976
Orleans - { New réseau	1,070·625	1,156,200	708,000	449,600	419·968
Paris - Lyon - { Old réseau	2,250·625	8,576,080	3,358,240	5,217,840	2,318·336
Mediterranean { New réseau	337·5	355,920	237,630	118,240	350·336
Southern - { Old réseau	497·5	1,432,880	523,720	909,160	1,827·456
Southern - { New réseau	593·875	471,480	318,720	152,760	257·536
Chemin de fer de Ceinture (right side).	12·5	150,960	78,600	72,360	5,788·80
Various companies - -	274·375	150,960	162,080	73,480	267·84
Totals and averages -	10,290·625	27,855,360	12,521,320	15,334,040	1,490·112

The average number of trains, taken over the whole system was 20 per day, eight of which were slow freight trains, and the others passenger and fast goods trains. The speed per hour, including stoppages, varies from 28 to 48·6 miles.

From 20 to 34·4 for through trains.
From 17 to 31 for omnibus trains.
From 15·6 to 25 for mixed trains.
From 9 to 15 for slow freight trains.

The mileage of passenger and mixed engines during the year averaged 21,188; that of the goods' engines was only 15,000. The average number of vehicles per train was 9 or 10 for passenger trains, and 36 for goods trains.

Tables V. and VI. show the movement of heavy freight, and passengers for each of the six companies, and for the others collecting, during the year 1869.

TABLE V.—GOODS TRAINS.

Names of Companies.	Mean length.	Numbers of Tons	
		For the whole distance.	For 1 mile.
	Miles.		
Northern - - -	928·	8,074,000	573,210,625
Eastern - - - -	1,708·500	7,685,000	698,096,875
Western - - - -	1,358·500	3,847,000	327,220,000
Orleans - - - -	2,331·250	4,975,000	608,395,625
Paris-Lyon Mediterranean -	2,588·125	13,156,000	1,440,581,250
Southern - - -	1,090·625	2,468,000	243,095,625
The six great companies together	10,005·000	40,205,000	3,890,600,000
Chemin de Ceinture (Rive Droite)	12·500	1,524,000	9,615,000
Different companies - -	274·375	2,285,000	19,130,000
General results - -	10,291·875	44,014,000	3,919,345,000

TABLE VI.—PASSENGER TRAINS.

Names of Companies.	Mean length.	Numbers of Passengers	
		For the whole distance.	Per mile.
	Miles.		
Northern - - -	928·	14,571,000	337,700,000
Eastern - - -	1,708·500	22,751,000	436,533,750
Western - - - -	1,358·500	28,990,000	461,115,625
Orleans - - - -	2,331·250	11,779,000	408,646,875
Paris-Lyon Mediterranée -	2,588·125	20,689,000	691,866,875
Southern - - -	1,090·625	6,132,000	188,634,375
Total for the six great companies	10,005·000	104,912,000	2,524,497,500
Chemin de fer de Ceinture (Rive Droite) - - -	12·500	3,576,000	14,021,250
Various companies - -	274·375	2,685,000	28,706,875
General totals - -	10,291·875	111,164,000	2,567,225,625

The State derives direct and indirect profits from the railways. The former arise from absolute receipts, the latter consist of economies effected in the cost of conveying passengers and material. During 1869, considering the 1,005 miles worked by the six great companies, and only 104 miles belonging to the secondary companies, we find that 1,685,880*l.* were realised from direct profits, and 2,297,440*l.* from indirect sources.

These receipts are divided respectively as follows :—

	£
Ten per cent. duties on passengers and high speed goods	1,306,800
Dues levied on the coal and coke consumed by the companies - - - - - -	32,800
Ground rents, &c. - - - - -	102,400
Receipt stamps, &c. - - - - -	243,880
Total - -	1,685,880

The economies realised were made up as follows :—

Reduction of price in carrying soldiers and sailors -	970,200
Transport of prisoners - - - - -	39,960
Free passes for the Customs' collectors - - -	19,120
Postal administration - - - - -	1,099,320
Telegraph administration - - - -	92,160
Transport of war material - - - -	37,280
Transport of administration finances - - -	39,400
	2,297,440

This profit represents nearly 10 per cent. on the capital expended by the State upon the railways.

The working staff employed is divided into four classes : the central administration; movement and traffic management; traction and material; roads and structures. The total number employed in 1868 was 138,247, divided as follows :—

Managers and clerks of all grades - - -	37,400
Drivers and firemen - - - -	7,532
Women employées - - - - -	10,344
Foremen, &c. engaged by the year - - -	32,108
Workmen engaged by the day - - -	50,863
Total - - - -	138,247

Table VII. shows how these servants are divided amongst the various rail ways.

TABLE VII.—GENERAL STATE of the EXPLOITATION. PERSONS EMPLOYED.

Names of the Companies.	Central administration.	Traffic.	Traction and Material.	Roads and Buildings.	Total number of persons (workmen included).
Northern - - -	146	8,446	4,907	7,106	20,605
Eastern - - - -	293	7,162	7,171	9,966	24,592
Western - - - -	528	7,717	4,668	6,938	19,851
Orleans - - - -	314	7,558	5,307	7,777	20,956
Paris-Lyon Mediterranée -	301	18,164	9,616	9,940	38,021
Southern - - -	223	4,324	2,321	4,491	11,359
Total for the six great companies	1,805	53,371	33,990	46,218	135,384
Different companies - -	223	1,168	540	932	2,863
Totals and averages - -	2,028	54,539	34,530	47,150	138,247

Of the 866,000,000 passengers conveyed on the French railways from 1859 to 1869, a period of 10 years, 63 have been killed and 1,150 injured, in 557 railway accidents. Through their own imprudence, carelessness, and other causes, 125 passengers have been killed and 530 injured. In 1869 there were 76 railway accidents, killing two and injuring 135 passengers. From other causes during the year, 22 were killed and 241 injured. In the same year nine servants of the companies were killed by accidents, and 166 through their imprudence and other causes.

The total of 405,540,000*l.* for the construction of 13,742 miles conceded on the 1st January 1870, is divided as in Table VIII.

TABLE VIII.—FINANCIAL SITUATION on the 1st January 1870.

	Past Expenses.	Future Expenses.
	£	£
States' Expenditure - - -	40,400,000	25,140,000
Companies' „ - - - -	275,516,000	62,760,000
Various companies' expenditure -	1,376,000	348,000
	317,292,000	88,248,000
	£405,540,000	

The State expenses correspond to the subsidies, either in money or works. The expenses of various interests (departmental, communal, and industrial) also correspond to subsidies, and are met by the local treasuries. To the companies belong all the outlays not covered by the preceding guarantees. A part of these expenses correspond to the works executed by previous concessionaires. Another part, valued at 12,840,000*l.*, corresponds to earthworks and *travaux d'arts*, executed by the State, on behalf of the railway companies.

Internal Navigation.—The system of internal navigation in France, forms a vast réseau, by which communication can be effected throughout the

country. By means of the artificial routes formed either by adapting natural water-courses, or by making canals, the Seine, the Rhine, the Rhône, the Gironde, and the Loire are directly connected. Paris is the natural centre of the system. From this point of departure, circumscribed by a vast sweep, formed by the canals Saint Denis and Saint Martin, with part of the Seine, various great water-ways diverge towards: 1. The channel (port of the Havre, and Somme Bay). 2. The Pas-de-Calais (ports of Calais, Gravelines and Dunkerque). 3. The Belgian frontier (towards Furnes, Gaud, Mons, and Charleroy). 4. The Swiss frontier (towards Bâle). 5. The Mediterranean (Ports of Boue and Cette). 6. The Atlantic (Ports of Nantes and Brest). A line from Bordeaux to Cette, completes the list, and makes a junction between the Atlantic and Mediterranean.

The navigable ways of France are divided into canals, canalised rivers, and rivers non-canalised. The collective length of frequented canals, is 2,971 miles, and that of canalised rivers is 2,077 miles. Of rivers non-canalised the effective length is about 2,000 miles. With the exception of a length of about 600 miles, all the navigable ways are administered by the State, the maintenance of old, and construction of new works is entrusted to the service of the Ponts et Chaussées, and the navigation dues are officially collected.

The tables Nos. IX and X, show the outlay which has been incurred by the State since 1814, for the service of Inland Navigation; their expenses amount altogether to 46,928,600*l.*

TABLE IX.—EXPENSES incurred by the STATE on account of INLAND NAVIGATION.

1. *Extraordinary Expenditure.*

	1814–1830.	1831–1847.	1848–1851.	1852–1870.
	£	£	£	£
Rivers	263,520	3,711,400	806,560	6,094,040
Canals	5,703,640	9,938,440	702,880	2,627,880
Total	5,967,160	13,649,840	1,509,440	8,921,920
		29,848,360		

TABLE X.

1. *Ordinary Expenditure.*

		1814–1830.	1831–1847.	1848–1851.	1852–1870.
		£	£	£	£
Rivers	Maintenance	1,344,320	907,880	224,560	1,307,160
	Heavy Repairs	»	—	—	—
	Special Repairs	»	1,131,320	220,360	981,000
	Credit	»	—	—	—
Canals	Maintenance	»	2,046,960	663,680	2,725,520
	Heavy Repairs	»	1,113,960	462,240	2,421,280
		»	—	—	—
		»	440,120	211,440	878,440
Totals		1,344,320	5,640,240	1,782,280	8,313,400
			17,080,240		

Table XI.—Navigable Canals.

Numbers.	Names of the Canals.	Length of Miles.	Width at the Line of Flotation.	Depth of Water.	Locks.			Expenses incurred up to 31st Dec. 1870.		Tonnage in 1868.		Numbers.
					No. of Sluice	Minimum Width.	Minimum Length.	Total.	Per Mile.	Mile Tons.	Average.	
		Miles.	Feet.	Feet.		Feet.	Feet.	£	£	Tons.	Tons.	
1	Aire to the Bassée { Canal properly said	26·50	52·48	5·41	2	17·05	139·10	120,000	4,531	16,312,500	615,600	1
	{ Branch of Noeux	1·50	39·20	6·56	„	„	„	6,000	4,000	99,375	65,800	
2	Aisne to the Marne	36·12	49·21	5·41	24	17·05	121·33	830,000	22,854	14,967,250	412,200	2
3	Aisne (lateral canal)	32·18	48·54	5·25	8	17·05	121·33	233,260	7,232	13,960,000	433,700	3
4	Ardennes and Branch of Vouziers	62·50	49·90	5·90	48	17·05	122·76	585,960	9,376	7,268,750	116,300	4
5	Arles to Bouc	29·62	73·47	6·56	4	26·24	172·25	473,160	15,968	3,638,750	122,800	5
6	Beaucaire { Ligne principal	37·14	52·48	4·92	5	21·64	103·56	540,000	11,104	2,687,500	55,300	6
	{ Canals of Bourgidou and Sylvéréal	11·43	31·0	6·56	2	21·64	120·48					
7	Bergues to Dunkerque	5·37	75·50	6·23	2	17·05	324·72	23,000	4,281	608,125	113,100	7
8	Berri	201·56	147·60	4·92	114	8·83	91·18	1,077,600	5,344	54,603,750	270,800	8
9	Blavet	37·20	104·96	5·25	28	15·39	101·02	235,320	6,316	472,500	12,700	9
10	Bouc to Martigues	2·68	51·34	19·68	„	„	„	107,480	39,993	134,375	50,000	10
11	Bourbourg	12·81	55·76	5·47	3	17·05	213·20	45,680	3,565	4,023,125	314,000	11
12	Bourgogne	151·25	40·90	5·90	191	17·05	111·52	2,231,760	15,084	24,651,250	162,900	12
13	Briare	36·93	36·08	4·26	43	17·05	113·15	524,000	14,182	10,564,375	286,000	13
14	Brusche	13·31	55·76	4·26	11	14·76	191·55	32,000	2,400	381,875	28,700	14
15	Caen to the sea	8·75	52·50	14·76	1	111·52	328·0	420,600	48,064	2,500,000	285,700	15
16	Calais and branches of Ardres and of Guines	26·50	48·54	5·90	2	26·050	142·20	156,440	5,900	2,553,750	96,700	16
17	Centre et rigole de Torcy	75·56	49·20	5·47	83	16·05	114·45	744,560	9,843	21,084,375	278,900	17
18	Charente to the Seudre	22·12	49·20	6·50	„	„	„	120,960	5,465	176,875	8,000	18
19	Colme and branch of Hondschoote	23·93	36·08	5·41	3	16·05	150·84	72,000	3,008	2,607,500	111,400	19
20	Coutances	3·50	32·8	4·26	4	13·77	67·24	23,080	6,592	18,750	5,400	20
21	Deule { Principal line	41·06	54·12	5·47	7	16·05	137·96	385,160	7,382	26,751,875	651,500	21
	{ Branch of Séclin	2·75	34·44	4·26	„	„	„	17,200	6,253	29,375	10,600	
22	Dive and Thouet	26·75	43·03	5·25	11	17·05	112·17	80,560	3,008	750,000	28,000	22
23	Dunkerque to Furnes	8·75	36·08	5·41	1	17·05	160·08	64,880	7,411	812,500	92,800	23
24	Etangs { Principal line	26·87	59·04	6·56	1	21·84	111·42	289,360	10,425	2,808,750	101,200	24
	{ Branches of Carnon, Perols, and Grau	0·87	50·51	5·90	„	27·24	„					
25	Eu to Treport	2·25	62·12	13·60	1	„	131·20	24,800	11,202	25,000	11,100	25
26	Garonne (lateral canal and branches)	131·62	57·50	7·21	72	19·68	116·4	2,504,000	19,020	10,212,500	78,300	26
27	Givors	11·56	45·92	5·25	43	14·76	91·90	188,000	16,256	905,000	78,300	27
28	Canals of Hazebrouck	15·68	22·96	5·24	5	11·64	298·50	16,000	1,036	285,000	18,500	28
29	Ill { River Ill canalised	4·50	98·40	5·25	3	17·38	128·37	77,080	17,126	1,125,000	101,500	29
	{ Canal of Ill to the Rhine	1·37	90·85	6·76	2	39·12	180·72	53,600	38,982			

Numbers.	Names of the Canals.	Length of Miles.	Width at the Line of Flotation.	Depth of Water.	Locks.			Expenses incurred up to 31st Dec. 1870.		Tonnage in 1868.		Numbers.
					No. of Sluice	Minimum Width.	Minimum Length.	Total.	Per Mile.	Mile Tons.	Average.	
		Miles.	Feet.	Feet.		Feet.	Feet.	£	£	Tons.	Tons.	
30	Ille and Rance	52·93	49·20	5·25	48	15·59	95·12	593,360	13,206	2,123,125	40,100	30
31	Lez	7·12	59·04	6·56	3	32·8	120·704	18,400	2,579	112,500	15,800	31
32	Loing	30·93	44·68	4·32	23	16·05	108·24	240,000	7,758	11,681,250	377,600	32
33	Loire (lateral canal and branches)	128·93	48·54	5·25	53	16·05	113·48	1,357,840	10,525	39,568,750	306,800	33
34	Luçon	8·87	56·84	9·84	1	21·32	164·00	22,000	2,483	281,250	31,700	34
35	Lunel	7·0	34·44	4·92	„	„	„	44,000	6,284	93,750	13,400	35
36	Mardyck	2·50	50·84	5·47	„	„	„	12,000	4,800	212,500	85,000	36
37	Marne (lateral canal), from Dizy to St. Dizier	66·31	48·54	6·23	34	16·05	124·92	651,600	9,824	18,215,625	274,600	37
38	Marne to the Rhine and branches	198·50	48·54	5·25	181	16·05	124·92	3,020,000	15,219	73,400,625	369,900	38
39	Midi { Principal line / Branches of Sommail to the Nouvelle	150·62	59·04	6·56	106	19·68	101·68	1,440,000	8,316	15,312,500	88,400	39
		23·62	45·92	4·92	13	19·68	101·68					
40	Mons to Condé	3·18	55·76	6·56	2	16·05	124·15	37,200	11,673	3,036,250	952,500	40
41	Nantes to Brest	225·0	50·51	5·25	235	15·59	96·43	2,190,400	9,734	8,537,500	37,900	41
42	Neuffossé	11·25	52·48	5·74	6	17·05	131·20	160,000	14,220	7,515,625	668,000	42
43	Nivernais	109·62	47·12	4·92	116	16·70	108·56	1,342,080	12,224	8,458,125	77,100	43
44	Oise { Oise canalised / Lateral canal and Manicamp canal	65·12	114·80	6·56	7	27·24	167·28	246,480	2,855	145,832,500	1,690,800	44
		21·12	59·0	6·56	4	21·32	131·20					
45	Orléans	45·94	32·80	3·772	28	15·39	99·38	404,000	8,793	2,386,250	51,900	45
46	Paris { Canal of l'Ourcq / Saint Denis and Saint Martin's canals	67·31	32·80	4·59	10	10·49	192·86	1,448,000	21,651	18,013,125	267,100	46
		6·93	85·25	6·56	21	25·58	137·76	908,000	128,000	5,262,500	758,500	
47	Pont-de-Vaux	2·12	50·0	4·92	1	23·61	114·80	22,600	10,638	11,875	5,600	47
48	Saint Quentin aux branche of the Fère	60·18	52·48	4·92	35	16·72	123·	1,024,680	17,024	97,462,500	1,619,300	48
49	Rhône to the Rhine { Principal line, & Humuguc branch / Colmar branch	218·81	50·51	5·25	164	17·05	99·38	1,160,000	5,309	51,312,500	234,500	49
		8·3	50·51	5·25	1	17·22	99·38	74,120	8,915	410,000	49,300	
50	Roanne to Digoin	34·87	48·54	6·56	14	17·05	108·24	396,400	11,366	4,739,375	135,900	50
51	Sambre a l'Oise { Canal proper / Sambre canalised	41·76	52·48	4·59	38	16·79	136·12	504,000	12,038	28,000,000	670,000	51
		34·0	59·04	6·56	9	16·72	136·44	120,000	3,526	22,375,000	658,000	
52	Sarre (canal des houillères)	47·25	49·20	5·90	30	17·05	124·96	641,600	13,568	25,308,125	535,600	52
53	Seine (canal de la Haute), from Marcilly to Troyes	27·37	47·56	4·92	15	17·05	126·608	252,440	9,222	350,000	2,800	53
54	Sensée	15·62	59·0	6·56	3	17·05	136·12	84,240	5,388	9,326,875	596,900	54
55	Somme { from St. Quentin to Abbeville / from Abbeville to St. Valery	88·50	59·0	5·41	23	21·52	119·39	544,000	5,555	8,768,750	89,600	55
		9·50	104·96	10·80	1	28·18	902·					
56	Vire and Taute	20·43	39·36	4·26	6	13·796	75·76	61,600	3,014	500,000	24,500	56
	Totals and averages	2,974·00	- -	- -	1,955	- -	- -	31,434,480	10,579	835,788,750	281,300	

The canals are far from being uniform in their section, partly because of the different traffic they have to carry, partly because of the widely differing dates of their construction. Table XI (see pages 18, 19) gives a résumé of the canals opened to traffic, when the Franco-German war commenced; it shows the cost of construction, and the sections of each canal, as well as the amount of traffic for the year 1868.

The canals which were in course of execution when the war of 1870 broke out are not included in this table. These are the canals St. Louis, the Haute Marne, the Haute Seine, the Roubaix, and the Salines de l'Est.

The Saint Louis maritime canal is 2·23 miles long, between the Cour de Saint Louis on the Rhone, and the bay of Fos. It was sanctioned in 1863, and opened for traffic in 1871. The width is 98 ft. 6 in. at the bottom, and 197 ft. at the water line. The nominal depth of water is 19 ft. 8 in., and there is only one lock to provide for a fall of 5 ft. 11 in. It is 72 ft. 2 in. wide, and 525 ft. long. The landowners interested in this great work, undertook to cede the necessary ground to the State, and to pay after the completion of the canal 60,000*l.* The outlay upon the work has been 320,000*l.* or about 143,500 per *mile*, and the accessory works have amounted to 120,000*l.*

The canal from Maram to La Rochelle, was sanctioned in 1805, and the works were commenced the following year, being continued by convict labour until 1846. Up to the end of 1870, when there still remained 20,000*l.* of work to be done, there had been expended 512,000*l.* This canal is 14·5 miles long from La Rochelle to its embouchure in the Sevre-Niortaise, near Maram. Its width is 32 ft. 10 in. at the bottom, and 41 feet at the water level. It consists of a single reach, terminated by a lock at each end. These locks are 17 ft. wide, and 31 ft. 6 in. long. The normal draught of water is 5 ft. 3 in.

The extension of the Haute Marne canal from Saint Dizier to Doujeux for a length of 21 miles was sanctioned in 1868. The construction is the same as in the length between Vitry and Saint Dizier, and it contains 14 locks. The total cost of this work was 290,000*l.*

The extension of the Haute Seine canal was decided upon in 1860 from Troyes to Villebertin a distance of 12·5 miles. The construction of this length corresponds to that of the canal between Marcilly and Troyes. The cost of the work is 67,600*l.*

The canal of Salines de l'Est connects the city of Dieuze with the Sarrebrück collieries as well as with the canal from the Marne to the Rhine. Its construction was undertaken in 1808, but after about 50,000*l.* had been spent, the project was abandoned and resumed in 1860, when Government authorised the expenditure of 80,000*l.* The length of the canal is 11·7 miles; the draught of water is 5 ft. 3 in.; the width at the bottom is 24 ft. 7 in., and at the water-level 50 ft. The locks are eight in number, 13 ft. 5 in. wide and 78 ft. 9 in. long.

The canalised rivers of France have a total length of 2,077 miles, and these, with one or two very trifling exceptions, are administered by the State. The total expense which has been incurred in adapting rivers to navigation, from the sixteenth century up till the end of 1870, is as follows:

	£		£
Previous to the nineteenth century -	800,000	1848–1851 -	880,000
1800–1813 -	200,000	1851–1870 -	4,320,000
1814–1830 -	500,000		
1831–1847 -	3,300,000		£10,000,000

The non-canalised rivers of France prior to the reign of Louis Phillippe had but little money expended upon them. Only upon some of them, embankments had been formed to protect the surrounding country against inundation.

Marine Signals.—The condition and extent of marine signals around the coast of France was well shown by drawings and an official volume of statistics, completed to the commencement of 1872.

TABLE XII.—LIGHTHOUSE ILLUMINATION.

	Old System, with Colza Oil.					New System, employing Mineral Oil.				
	1st Order.	2d Order.	3d Order.	3d Order.	4th Order.	1st Order.	2d Order.	3d Order.	4th Order	5th Order.
Number of wicks	4	3	2	2	1	5	4	3	2	1
Average of the exterior diameter of the wick.	ins. 3·346	ins. 2·716	ins. 1·535	ins. 1·259	ins. 0·944	ins. 4·133	ins. 3·346	ins. 2·559	ins. 1·771	ins. ·984
Diameter of the jet	3·543	2·913	1·732	1·456	1·141	4·330	3·543	2·755	1·968	1·181
Diameter of the lenticular apparatus	72·441	55·118	39·370	19·685	14·763	72·441	55·118	39·370	19·685	14·763
Intensity of the light (in Carcel jets)	23	15	5	3	1·6	30	23	14	6·4	2·2
Brightness of fixed light without reflector.	630	335	90	30	13	820	510	250	64	18
Consumption of oil for each jet. per hour	grs. 11,704	grs. 7,700	grs. 2,695	grs. 1,694	grs. 924	grs. 13,860	grs. 7,854	grs. 3,850	grs. 2,464	grs. 847
Consumption of oil for each jet. per annum	lbs. 6,688	lbs. 4,400	lbs. 1,540	lbs. 968	lbs. 528	lbs. 7,920	lbs. 5,544	lbs. 3,168	lbs. 1,408	lbs. 484
Annual cost of oil at the average price of 1·208s. for colza, and ·68s. for mineral oil.	£ 183·60	£ 120·8	£ 42·28	£ 26·56	£ 14·48	£ 122·40	£ 85·68	£ 48·96	£ 21·76	£ 7·48
Number of lights Jan. 1, 1873	42	6	30	15	230	42	6	30	15	230
Annual cost of oil for each order of light.	£ 7,711·20	£ 724·8	£ 1,868·40	£ 398·40	£ 3,330·40	£ 5,140·8	£ 514·08	£ 1,468·8	£ 326·4	£ 1,720·40
Total annual cost	£13,433·20.					£9,170·4.				

Note.—The unit adopted is the Carcel jet ·787 in. diameter, and consuming 617 grains of Colza oil per hour.

At that time there were 330 signals distributed around the French coast, and of the following classes :

Lighthouses of the first order - - -	45
„ „ second „ - - -	6
„ „ third „ - - -	44
„ „ fourth „ - - -	225
Floating lights - - - - -	10

Besides these there were the smaller signals, namely :

Timber or iron buoys - - - -	1,165
Signal stone towers - - - -	201
Common buoys - - - -	659
Buoys with bell signals - - -	32
Other floating signals - - - -	924

During the year 1872 much progress was made in the construction of other lighthouses, and six new ones were illuminated during that year; so that at the commencement of 1873 the total number was 336, of which 241 have been either rebuilt, or are newly erected since 1848. Colza oil is largely employed for illuminating. The electric light is seen from three towers, and mineral oil is used in 231 others. In March 1873 the Minister of Public Works decreed that mineral oil should be substituted in all cases for the colza oil, except in the cases of floating lights; and at the same time it was decided that the number of wicks for the three first orders should be increased by one. Table XII. (see page 21) is of interest as showing the condition of lighthouse illuminations in France at the date of the change, and the advantages that will arise from the alterations, based upon the trials that had been carried out.

The foregoing table shows an increase of 40 per cent. in the intensity of light obtained, and a diminution of 30 per cent. in the cost of production.

A practical difficulty of considerable importance impeded the introduction of the mineral oils for lighthouses; the oil burnt well in single wicks, but it was not until 1868, when Captain Doty perfected his multiple system, that success was achieved.

We may now proceed to notice briefly the principal lighthouses of which detailed drawings were exhibited at Vienna.

The first of these is the iron structure which figured at the Paris Exhibition of 1867, and was afterwards removed and erected on the Grand Signal Rock, part of the plateau Roches-Douvres, between the Isle of Brèhat and Guernsey. The rock on which the lighthouse stands is a metamorphic gneiss, very hard, and affording excellent material for foundation, the masonry of which is rubble set in Portland cement. The foundation is cylindrical in form, 49 ft. 3 in. diameter and 4 ft. 3 in. high, surmounted by a truncated cone, 47 ft. 6 in. diameter and about 9 ft. high, and upon this was placed the iron tower. The work was commenced in 1867 and the first illumination was made in 1869. The total cost of the structure, lighting apparatus, &c., was 24,214*l.*

The Four lighthouse (Finisterre) stands on a rock advanced into the sea, about two miles west of the little port of Argenton. The rock is of hard granite, and stands about 6 ft. above high water. The lighthouse consists of a tower the interior diameter of which is 14 ft. 8 in., placed on a massive masonry foundation raised 6 ft. above the highest tides, and sunk in the rock, the highest parts of which it encloses. The walls are 9 ft thick at the base and 3 ft. 10 in. at the top. A coping and parapet surmount the wall.

The tower rises to a height of 74 ft. 5⅝ in. above the foundation, and carries at the elevation a polygonal turret 7 ft. 9 in. diameter, which supports the lantern. The height of the light above the sea is thus about 92 ft. The tower consists of a ground floor and five upper storeys.

These various stages are connected by a staircase, straight from the ground to the first floor, and thence circular to the top of the tower. The staircase comprises 94 steps, and is formed partly in the thickness of the wall. The ground floor is divided into three compartments, a vestibule and two cellars lighted each by a window 19in. by 10in. One of these is for coal, of which it can hold five tons, and a pump for the water supply. The other cellar forms the oil store. The first floor forms a magazine, and contains 22 iron tanks,

holding five tons of fresh water, and in addition two tons more coal. The upper storeys give accommodation to the men.

The fog-horns which are employed during foggy weather, are actuated by compressed air stored in a reservoir. The apparatus consists of two vertical four-horse Field boilers, of the horns, and of suitable mechanism, actuated by the engine for opening and closing periodically the communication of the boilers with the trumpets, so that a signal is given every five seconds.

The Four lighthouse was commenced in 1869, and it was intended that the whole of the work should be completed at the end of last year. The estimated cost is 10,600*l*. M.M. Planchat and Fénoux were the engineers, and the lamps were made by M.M. Henry and Lapaute.

The lighthouse of Ar-men on the island of Sein is situated at the extreme western end of the department of Finisterre. The island extends in a westerly direction with a series of reefs disappearing out to sea, and reaching for a distance of eight miles from the island. Some of these reefs stand high above water, and others are uncovered only at low tides, the majority, however, are constantly submerged. They form a natural breakwater, the direction of which is almost normal to that of the local currents, and the sea therefore breaks over the chain of reefs with extraordinary violence. The singular formation is known as the "Chaussée de Sein," and was so fertile a cause of maritime disaster that a commission was established in 1825 to provide a suitable signal at this dangerous spot. It was first proposed to erect two first order lights, one on the Point du Raz, and the other on the Ile de Sein, but it was afterwards determined to erect a tower on the furthest of the reefs. In 1860 a careful survey was made, and three conspicuous rocks were examined, known respectively as the Madion, Schoemer, and Ar-men. The two first named were hardly visible, and the third raised itself about five feet above the lowest sea level. The size of the Ar-men rock, however, appeared too small for the purpose, and accordingly another rock, about five miles from the extremity was recommended. After prolonged discussion this scheme was abandoned, and in November 1866 the lighthouse commission decided that an attempt should be made to construct the masonry foundations of the lighthouse on the Ar-men rock. Up to this time no one interested in the question had been able to land and examine the site. It was known to have a width of 25 or 30 feet, and a length of from 40 feet to 50 feet at low water; that its surface was very irregular, that it was intersected by deep fissures. Later fragments were obtained, which showed that it consisted of hard gneiss, decomposed, however, in places. It was intended in the first place to bore holes in the rock, about 12 inches in depth and 3 feet apart over the area to be occupied by the foundation, and outside this space to make other holes for securing the rings for the tackle and moorings required. The fissures were to be filled up with masonry, and the latter was to be strengthened horizontally with chains, as it was built.

The work of boring the holes was entrusted to the local fishermen, who commenced operations in 1867. These boring operations were tedious and perilous in the extreme, and although no time was lost, there were only about 30 yards of masonry executed at the end of 1869. The vessels carrying material could only approach in calm weather, and the men were always obliged to work with cork jackets to aid them in the event of their being swept away. At the present time the foundations are raised above the highest sea level, and the work will henceforward be easier and less dangerous. The foundations thus made have a diameter of 23ft. 8in., a dimension fixed by the size of the rock itself. The diameter of the tower will vary from 9 ft. 10 in. at the base to about 7 ft. at the top, and the thickness of the wall will decrease from 5 ft. 9 in. at the bottom to 2 ft. 7½ in. at the top.

Miscellaneous.—Amongst other drawings, models, &c., exhibited, we may briefly mention:—

1. Those referring to the Duzon viaduct, built some four years ago, about four miles from Tournon, in the Ardèche.

2. The drawings of the new passenger station at Paris, belonging to the Orléans Railway Company, at a cost of 720,000*l*.

3. The Viaduct de Bouble, erected by the same company on the line from

Commentry to Yannat. This structure was completed in 1871, by M.M. Nordling, Delorn, and Geoffray, M.M. Cail & Co., of Fives-Lille, being the contractors. The following are some dimensions of the viaduct:—

Total length - - - - -	1,295 feet.
Maximum height above water level - -	214 „
Average height „ „ „ - -	148·2 „
Total cost - - - - -	44,000*l.*
Cost of each main pier - - -	4,640*l.*
„ per foot run of girder - - -	51·33*l.*

4. The embankment of the Seine. Plans of this work were shown at the Paris Exhibition in 1867, and included a general plan and longitudinal section of the river from Rouen to the sea. These exhibits, however, were not reproduced at Vienna, and they consisted of a chart showing the actual condition of the Seine at the present time. Since 1867, more than a million and a half of francs have been expended upon the construction and repair of dams, and in making and maintaining channels, to the great advantage of navigation.

5. The great water way, connecting the Havre, Rouen, and Paris, to Lyon and Marseille by the rivers Seine and Yonne, the Bourgoyne canal, and the Saône and the Rhone, was until September 1871, wanting a link from Paris to Laroche, where the Bourgoyne canal falls into the Yonne, for a distance of 118 miles. Indeed, during eight or nine months of the year, from March to November, the descent of boats was impossible, especially on the Yonne, which had but a maximum four feet, so that barges drawing a greater depth of water, were obliged to discharge cargo at Laroche. The traffic lies mostly in one direction, so that the up barges were of very light draught.

Since September 1871, however, the navigation between Laroche and Paris has been made continuous, by means of seventeen moveable dams constructed on the Yonne, by two new feeders, and by twelve new moveable dams on the Seine. The minimum draught of water in the reaches is now 5 ft. 3 in., so that all barges can travel in both directions and in perfect security. In order to make the importance of this work clearly understood, it is necessary to explain the nature of the navigation, and to commence by the river Yonne, the principle affluent of the Seine.

The river Yonne, between its source in Morvan and its discharge at Montereau, passes through the three departments, the Nievre, Yonne, and Seine-et-Marne, having a length of 180 miles, and may be divided into three distinct sections, according to the mode of transport for which the river is utilized. The first section, about 60 miles long, extends from the source, near the marshes of Belleperche, as far as Armes, near Clamecy; it carries large quantities of timber, cut from the woods, and which is collected near Clamecy and formed into rafts, which are afterwards loaded up into boats for Paris.

The second section from Armes to Auxerre has a length of about 45·5 miles, with 23 weirs; the barges travelling between these points employ the canal which runs parallel to, and sometimes joins the river. The third section, 74·5 miles long, from Auxerre to Montereau, is navigable always both for barges and rafts. It is sub-divided into two sections, the first between Auxerre and Laroche, that is to say, between the outfalls of the two canals of Nivernais and Bourgoyne. A length of 17 miles is still affected by the régime of the locks, or of intermittent navigation, but the improvement works, which will secure a continuous navigation in this section, are in course of execution. The second section lies between Laroche and Montereau, and is 57 miles long. On this second section, the régime of locks, or of intermittent navigation ceased to exist in 1871, when the moveable dams were constructed.

So long ago as August 1861, a decree had been made, declaring of public importance, the new works intended to procure a constant minimum depth of 5 ft. 4 ins. in the Yonne, between Laroche and Montereau, and the cost of which was estimated at 208,000*l.* A second decree, dated July 1868, referred to the expenditure of 120,000*l.* for similar works between Auxerre and Laroche.

After investigation, it was decided that the width of the locks should be 34 ft. 5 ins., and their length 315 ft. To obtain a straight and more direct route, four new channels were cut, reducing the distance between Auxerre and Montereau by 12,800 yards. The width at the bottom of each cut is 52 ft. 6 ins., and the normal depth of water is 5 ft. 11 in., with slopes of $1\frac{1}{2}$ to 1, so that the width at the water level is 70 ft. 2 ins. The side paths are from 13 ft. to 20 ft. in width, and are placed 18 ins. above the level of highest known flood.

The weir at Île-Brûlée is furnished with a system of sluices invented by the late M. Girard. This system consists:—1. Of a series of large wooden sluices moving around a horizontal axis, which is free to turn in bearings, placed in the top of an invert. 2. Of a series of hydraulic presses anchored to the masonry of the dam, and employed to operate each sluice. The piston of each of these presses carries a cast iron cross piece, and working in suitable guides, to this cross piece are attached three links coupled to a second cross piece, bolted to the middle of the movable sluice. 3. A system of pipes connecting the presses with the accumulators. 4. Pumps and accumulators placed at the side of the dam. The sluices are worked by manipulating three way cocks, by which each press may be placed in communication with the pumps or accumulator in order to produce the upward motion of the piston, and consequently the raising of the sluice. On the other hand by opening the discharge pipe the water escapes under the pressure of the sluice, which then falls.

The Seine forming a great link in this system of water communication, takes its rise in the department of the Côte-d'Or, but is only navigable from the village of Marcilly (Marne) where the river Aubre, and the Haute Seine canal join it. Between Marcilly and Paris, a distance of 117 miles, the river is known as the Haute-Seine; it is divided into two sections, the Petite Seine between Marcilly and Montereau, and the Haute Seine proper, from Montereau to Paris. In 1846, seven millions of francs were granted for the improvement of this water way, and several weirs above Montereau were made together with one immediately below that point, in order to preserve the reaches upon the Yonne. In 1859 it was decided that three additional weirs should be made below Montereau, at Champagne, Melun, and Évry. In 1868 the project was approved for 12 large locks and weirs between Montereau and Paris, including those just named, and these have been constructed on the Chanoine system, mentioned already as being employed upon the river Yonne.

The following is the expenditure incurred upon this work.

1. *Upon the Yonne between Auxerre and Montereau.*
(Length of river canalised, 118,328 yards).

	£
Seven locks and weirs between Auxerre and Laroche	88,760
Weir of Gurgy, without lock	5,600
Eight locks and weirs from Laroche to Sens	147,840
Weir of Toigny, without lock	6,800
Seven locks and weirs, from Sens to Montereau	157,080
Weir of Courlon, without lock	8,000
	414,080
Feeding canals	121,275
Dredging, embankments, improvement of tow paths, &c.	137,607
Total expenditure between Auxerre and Montereau	672,962

2. *On the Seine between Montereau and Paris.*
Length of river canalised 321,440 yards.

	£
Five locks and weirs, between Montereau and Melun	161,856
Six locks and weirs, between Melun and Ablon	207,416
Lock and weir of Port-à-l'Anglais	63,229
Dredging, embankment, tow paths, &c.	141,660
	574,161

The application of dynamite.—The first experiments made with dynamite for breaking up ice upon a river, were conducted in Paris during the siege, with the object of setting free the gun boats frozen up in the Seine, at the Porte-a-l'Anglais. These trials gave a very poor result, the dynamite cartridge exploded on the ice, making holes through it, but nothing more, and it was found more expeditious to cut through the obstacles with hatchets.

In December 1871 similar and unsuccessful trials were made at Pontailler on the Saône, to relieve a bridge threatened by the accumulation of ice, and during these trials M. Gobin, Engineer des Ponts et Chaussées at Lyon, conceived a new mode of employing the explosion which proved very successful.

The duration and intensity of the frost, during the winter of 1871, throughout France, produced vast collections of ice upon the rivers, and those upon the Rhône, at Lyon, seriously endangered the safety of the floating baths and establishments moored in the stream. It was then that M. Gobin made some experiments to clear a channel with the aid of dynamite, and at first exploded cartridges covered with a layer of sand or clay; this produced a hole simply, without large cracks, and always following the line of least resistance. In order to detach a block from a mass covering a large surface, it was necessary to produce a horizontal pressure directed from the bank.

At about 50 feet from the free side of the ice, which had a thickness of 7 in. to 8 in., a groove parallel to this edge was made with a hatchet, 3 ft. 3 in. long and 1½ in. or 2 in. deep; this furrow had the form of a V, the side nearest the edge being vertical. The dynamite was enclosed in a sausage, 3 ft. or 3 ft. 10 in. long, surrounded with sawdust and waxed paper to keep out the frost. This cartridge was placed in the groove, and covered with a layer of sand 1½ or 2 in. thick. The explosion resulted in several fissures, principally parallel to the edge of the ice, and 100 ft. or 150 ft. long on each side. In one instance a crack extended 190 ft. in one direction and 500 ft. in the other. The charge employed was only 210 grammes of No. 3 dynamite. The blocks thus detached were enormous, measuring from 1,000 to 2,000 square yards, in three or four pieces. To divide these up the following method was employed:

In the centre of the block, about 30 feet from the sides, a hole three or four inches in diameter was bored, and through it was passed an ordinary cartridge with a match encased in gutta-percha. A piece of wood was fastened to the match and rested on the surface of the ice, keeping the cartridge in position. The length of the match was sufficient to suspend the cartridge about 3 ft. below the ice, a distance which experience showed to be the most suitable. If the ice was thicker than already mentioned, it was necessary to reduce this distance, and *vice versâ*. These cartridges contained only from 17 to 35 grammes of dynamite, and their explosion produced radial cracks from 30 to 100 ft. long, which opened soon after the explosion.

If heavier charges of dynamite were employed, the depth below the ice was increased to 5 ft., and thicker and larger masses could be dealt with. It was found more difficult to operate with thin ice, and it then became necessary to mix a little sawdust with the dynamite to moderate its effect. By this means it was found possible to break up more than 50,000 square yards of ice in a single day, four men being employed, and the cost not exceeding 32*s*.

M. Fontaine, Engineer des Ponts et Chaussées at Dijon, employed the same process to clear the bridge of Pontailler mentioned above, and reported as follows on the 6th February 1872: "We have just saved our bridge at "Pontailler, which was extremely light, and in serious danger. We had "already, by the aid of dynamite, broken up the ice into masses 100 or "150 ft. wide and 4,000 ft. long; and after employing 60-gramme cartridges, "placed 5 ft. below the ice, we broke up masses measuring 6,000 or 7,000 "square yards into 10 or 15 pieces. By this means we broke up 1,200 tons "of ice, a weight 20,000,000 times greater than that of the charge employed."

Similar and equally successful results were obtained upon the Canal de Berry.

The gutta percha fuzes employed for this work are sold in lengths of 10 or 11 yards, at the price of about 1½*d*. a yard. It is necessary to preserve them in a warm place, as the gutta percha hardens and cracks, so that it will admit water to the fuze. It is always better to guard against possible faults by

rubbing the fuzes over with tallow. The single capsules cost 2*s.* 6*d.* per hundred, and the double ones 4*s.* 8*d.* per hundred. The latter are preferable because they are more easily attached, and give a stronger explosion. To fix the capsule to the fuze, the end of the latter is pointed and introduced to the former till it touches the fulminate, then with a pair of pliers the opening of the capsule is locked upon the fuze. To make this connection water-tight, it is well to cover it with a rubber ring, cut from a tube of rather smaller diameter than that of the capsule. This latter is then placed in the cartridge and fastened to it by a ligature, care being taken that the cap stands above the level of the dynamite in order that it may not be ignited by the fuze before the latter has reached the fulminate. If the dynamite is handled care should be taken to wash the hands immediately, and in no case to touch the face with them; the early experimentors found to their cost that doing so was attended with intense pain in the head.

It is as well to mention that the explosion of dynamite in water brings all the fish within the range of the shock to the surface, stunned or dead, the larger ones generally recover, the small ones do not. This effect, however, is not noticed in winter, when the fish are hidden under stones or in holes sheltered from the explosion.

The process thus described has obviously many important applications, as, for example, the setting free of a frozen-up ship, or in time of war preventing an enemy from crossing a frozen river, in clearing the fosse of a fortification from ice, &c.

In conclusion it should be mentioned that the dynamite employed was manufactured at the works at Paulille (Pyrénées Oriéntales), and that its application was illustrated by various plans and models at the Exhibition.

Italy.

Of civil engineering Italy made one remarkable exhibit, a full-sized model of the Italian entrance to the Mont Cenis Tunnel. This occupied the garden court adjacent to that part of the Industry Palace allotted to Italy. The model formed a shelter for examples of locomotives, rolling stock, &c., employed upon the Italian State railways, and which are fully noticed in another section. The present is the fitting place to speak at some considerable length of the great work thus strikingly represented at Vienna.

The construction of the tunnel under the Alps, between Bardonnèche and Modane, was commenced, in accordance with a Bill passed in the Italian Parliament, on the 15th of August 1857. The official sanction to this Bill was given after the Committee appointed by the Government with the object of examining the project for the tunnel that had been presented by the Italian engineers, Messrs. Grattoni and Sommeiller, had delivered their report. This report referred especially to the mechanical appliances proposed for the carrying out of the work.

At the time that the Bill was issued the preparatory designs alone were ready, together with the models of the machinery with which the Government Commission had made their experiments. Although all the fundamental ideas of the engineers were clearly expressed, and the possibility of executing the work was materially proved by experiments before the colossal undertaking was commenced, the technical directors felt obliged to execute the working designs of the whole project, and to study carefully each separate part. This is why the preparatory and external works only could be proceeded with in the same year, 1857.

The plans previously developed under the direction of Mr. Mans, and followed out by his colleague, Mr. Bombeaux, an engineer of great experience and undoubted practical ability, were taken as a guide in deciding upon the works that were to be at once commenced on each side of Mont Frejus. The two chief points having been fixed, and the general direction of the axis of the tunnel having been approximately determined, excavation was begun at both extremities by hand labour alone, and continued till the mechanical system could be applied.

Before entering into further particulars, it may be found interesting to refer to the conditions of the locality in which the two industrial centres of the

works were to be established, in order to give an idea of the difficulties encountered at the commencement of the works, and which could hardly be conceived by those who were unacquainted with the two miserable Alpine villages, Bardonnèche and Fourneaux, before the head works of the great tunnel were established close to them.

Bardonnèche is a village situated at an elevation of more than 4,200 ft. above the level of the sea, and in 1857 it was populated by about a thousand inhabitants, a large proportion of whom even now, being shepherds, migrate from the village during the summer months to remote feeding tracks. The whole population, with the exception of the small number that crosses over to the south of France, and especially to Marseilles, live on the products of their own miserable fields, on their cattle, and by the rearing of mules. As the houses were built in accordance with the wants and very limited means of the people, and as their customs and mode of life were of the most primitive description, exceeding in poverty and rudeness those of the poorest villages of the plain, while, moreover, they passed the rigorous winter months crowded in stables amongst their cattle, it at first appeared hopeless to unite at Bardonnèche the necessary number of clerks and workmen to give a sufficient force at the commencement of the works. Not only were the most essential articles of food and of household necessaries wanting, but even the means of communication were insufficient for obtaining supplies. One of the first things to be done, therefore, was to provide for the repair and alteration of the houses, and at the same time to encourage the primitive arts and industries, without which it would have been excessively expensive, if not impossible, to keep the workmen in such a place.

Under these circumstances, for above two years, the engineers, clerks, and operatives had to submit to discomfort hardly conceivable by persons who have not lived in those wild Alpine districts during the winter season.

At Fourneaux the conditions of the locality were no better. Fourneaux is a village numbering barely 400 inhabitants, absolutely without any means whatever of ministering to the wants of an increased population. There were no lodgings, except in filthy stables, and no shops where the workmen could purchase an ounce of eatable food. The clerks and workmen were forced to quarter themselves at Modane, a village of some importance, but more than a mile and a quarter from Fourneaux, and for three years all were obliged to walk that distance, over rocks, marsh, and morass three or four times a day, exposed to all the inclemency of an extremely severe climate, and sometimes through snow five feet in depth.

Such were the conditions under which the external and preparatory works were begun.

These works consisted at first almost exclusively of masonry; and as building is very tedious in these regions, the progress was slow, for the masons can only calculate six months in which they can work, and even out of this time they must lose many days on account of bad weather.

The tracing of the axis of the tunnel was of the greatest importance, and it had to be undertaken and carried out as quickly as possible, so as to permit of the commencement of the excavation at both ends.

The problem to be solved was: 1. To fix across the mountain several points, which would all be contained in the vertical plane drawn through the axis of the tunnel. 2. To obtain the exact length between the openings. 3. To know the precise difference of level between the two extremities of the tunnel, so as to obtain the proper gradients.

These labours were first assigned to Messrs. Borelli and Copello, civil engineers. The first operation was to trace a trial line from the fixed point from the opening at Fourneaux towards Bardonnèche. This line, which was traced as rapidly as the position of the locality could permit, and with such a degree of accuracy as is necessary for a trial tracing, intersected the valley of Rochesmolles in a point much higher up in the valley than that previously fixed for the southern opening. Being guided by this first tracing, and re-starting from the northern opening, a second line was located, which terminated near Bardonnèche, very close to the spot which was aimed at.

Again taking the second tracing as a guide, a third axis was finally traced, which fully corresponded to the proposed conditions, as it passed by both the points previously fixed for the openings of the tunnel in the valleys of Arc and Rochesmolles. These first operations, although accomplished with the greatest possible despatch, and though the season was constantly favourable, could not be completed before the beginning of September, for much of the time was taken up by journeying to and fro between the opposite sides of the mountain, and dealing with the rugged and difficult nature of the ground over which the line had to be laid out. The approximate axis of the tunnel having thus been determined, it yet remained to be traced out in a definite and permanent manner, in order that the fixed signals might be set up, and the exact points found at which the observatories were to be erected at each opening as well as at the highest point of the mountain. This was done in the month of September, while excursions were also made to the highest peaks of the principal chain, and of the adjacent mountains, with the view of finding out the trigonometrical points of the Royal Engineering staff survey, and to fix the others, which would suit best as vertices of future triangulation. At the beginning of October, 1857, the most important fixed signals on the northern side, and all those on the southern were definitely settled, as well as the corresponding points of the observatory of the southern opening; and there only remained to decide the spot which was afterwards to serve for the northern observatory, and to fix definitely some secondary signals on the northern side of the mountain. At that time Mr. Borelli was called upon to superintend the local direction of the works, begun at Bardonnèche, and it fell to the lot of Mr. Copello, to complete the work still unfinished, relative to the tracing of the tunnel. The first falls of snow prevented the field work from being completed till about the middle of October, and on the 20th of this month such difficulties were met with in consequence of snow and wind, that the idea of continuing any work in that year had to be given up. At the same time, in which the tracing of the axis was going on, levelling was commenced along the mountain, direct from one opening to another, crossing the peak near Frejus, following as nearly as possible the axis traced on the mountain; and on the route were placed a number of altimetrical signals to be used in controlling the operations. The results of this levelling, after having been done twice, although not considered definite, were sufficiently in accordance to warrant the prosecution of the excavation at each end of the tunnel; especially as it was easy to compensate for the slight changes which might still be necessary to introduce in the arrangement of the gradients, when the ultimate studies for fixing the exact difference of level between the two entrances, and the precise length of the tunnel had been completed.

Towards the middle of July of the following year (1858), the trigonometrical operations which still remained to be done, were set in hand. These operations were preceded by the selection of those culminating points which were found to be best adapted to form the most suitable system of triangles, and the choice of a base among the sides previously traced out by the engineering staff, for the general survey of the country. This work, which took up all the second half of July, was executed by Mr. Copello. When the triangulation was completed, and the base of one of the triangles of the engineering staff, with which the new triangulation had to be brought into geodetical connection, was chosen, the measurement of the angles of the system was immediately proceeded with, beginning from the highest vertices, and descending by degrees to the lowest points; first, on the side of Bardonnèche, and then on that of Modane. The complete operation, which includes 21 geodetical stations, and as many as 86 measured angles, each of which was checked over at least ten times, could not be finished before the beginning of October, 1858. In the same time, however, all the special points of the longitudinal section on the axis of the tunnel, could be divided out with sufficient exactitude; the respective distances being deduced, either by direct measurement or by the solution of the minor triangles (tied to the principal system), and the heights of which, found by

direct levelling, were brought into geodetical connexion with the fixed altimetrical signals across Mont Frejus.

During this period the observatory, placed on the highest point of the mountain, was erected, and having thus assured for the instrument and the operator a shelter against the furious winds which rage on those bare rocks, the tracing of the axis of the gallery could be re-undertaken and verified with the greatest possible precision. Finally, in that same surveying campaign, Mr. Mondino again completed a set of direct levels between the headings of the tunnel, by which new operation the difference of their respective altitudes was ascertained with perfect accuracy. At the end of the season, 1858, all the surveys relating to the alignment and to the length of the tunnel were terminated, and everything was ready to compile the longitudinal section along the axis of the tunnel.

Having thus sketched out in chronological order the different preliminary surveying and levelling operations, which were undertaken to ascertain the exact position and the gradient of the work, as well as for the measurement of its length, we may proceed to consider the way in which these operations were carried out.

The longitudinal section, Plate 252, will explain the reason for the method that was adopted. Looking from the summit of the Grand Vallon, which stands almost midway between the two entrances to the tunnel, and on the highest point of the chain intersected by its axis, it will be seen that the southern side towards Bardonnèche, offers only two remarkable points, the one at Q, which marks the crowning of the torrent Merdovine, and the other, S, which is on the summit of Banda. On the northern side there is a spur which commences near the observatory placed on the top of the mountain, and then continues to slope downwards, following very nearly the direction of the axis of the tunnel, by which it is met at three points M, T, and F, corresponding to Vallonet, La Ronda, and Lachalle, so called from the names of the summits on which they stand.

Between Lachalle and the bottom of the valley of the Arc, the only remarkable point in the side of the mountain is at E, where the line meets with the torrent of the Grand Vallon. The axis of the tunnel being prolonged on the southern side beyond the torrent Rochemolles, the Millaures are met, and here the extreme point U was so fixed that the visual line passing through it and the observatory of the Grand Vallon should be tangential to the peak of Banda. On the northern side, the axis being prolonged across the valley of the Arc, and extended on its southern side, the observatory B of the entrance was erected, as well as the signal A of Pietra Bianca. It is easy to perceive that in order to obtain a point from which a visual line could be drawn to the principal observatory, it would be necessary to ascend to a great height, because of the Grand Vallon, and, therefore, the extreme point on this side had to be fixed at a great distance, and a considerable height When the approximate axis was determined, so as to meet the required conditions, namely, to pass through the two points fixed for the openings of the tunnel, the points where the principal observatory of the Grand Vallon was to stand, as well as that on the southern side of the valley of the Arc, which was to be the extreme point of Les Sapins, were definitely established. From the observatory of the Grand Vallon a third point was next fixed, which was the extreme station beyond the valley Rochemolles at Beauvon.

This very simple operation, which included all the tracing, was repeated and verified many times by various methods and from different observatories; the instrument used was a large theodolite by Lerieux, of Paris, and by it the signal placed at Les Sapins could be plainly seen at the observatory of the Grand Vallon, although the distance between them was at least 9,840 yards.

It was impossible to execute the tracing of the axis in the usual manner, that is to say, so that the ends of the line may be visible one from the other, unless at such a distance as to cause chances of serious error in the precision of the observations, whereas, even if any mistake inseparable from the workmanship of the instrument and from the method used, had occurred in

following out the system just described (*i.e.* of prolonging the axis byond the two entrances, and choosing an intermediate point where the extended terminals could be seen) the error would not have been of great consequence, because, if, for example, the mistake consisted in an angle of deviation, by turning the instrument round 180°, such an angle could only differ from the one given by the first observation of the vernier of the theodolite by at the utmost 10″, that is to say, the observatory of the Grand Vallon, instead of being placed on a straight line drawn between the two entrances, would be at the vertex of the two lines diverging at an angle of 10″. Now, such a mistake would give a deviation of 11·42 inches, a deviation to be remedied so easily as to give rise to no serious apprehension as to the correctness of the work.

The line having been selected by means of Les Sapins, the observatory of the Grand Vallon and Beauvoir, there existed no difficulty in fixing the other points. The south opening was worked by sighting Banda S from Beauvoir U, and then directing the instrument from Banda to Beauvoir was established the southern observatory T, from which the opening was worked. A similar operation for the north opening was somewhat more tedious to carry out, for it was necessary when sighting the instrument from the observatory of the Grand Vallon to Les Sapins, first to sight Vallonet M, and then, having removed the instrument to the position to continue the collimation, first, to the extreme part on the southern side of the Arc, to mark the Riond I, and the Pietra Bianera A, and then again to remove the instrument to the Rionda, and fix successively Les Sapins and Pietra Rianca to mark Lachalle F, when, having carried the instrument to this last point and finally collimating at Les Sapins and Pietra Bianca, the position of the northern observatory B could be marked, and from it the northern opening, and another secondary observatory at Les Aysards D.

The most important peak on the northern side (owing to its being the furthest that could be sighted from an observatory at the opening) and which served to check the line of the tunnel in Lachalle, and it may be considered as fixed with the greatest exactness, so that even if some mistake had been made it would not seriously have affected the final result.

On the southern side of the mountain the point sighted for tracing the tunnel was Banda, this being the only one visible from the observatory of Bardonnèche, and which was only 2,624 feet from it, the visual line from the observatory of the Grand Vallon to the extreme signal at Beauvoir, passed over that of Banda, so that the point was fixed at the first moment without any vertical movement being made in the telescope of the instrument.

The trigonometical survey made to obtain the means for measuring the length of the tunnel had for its base the side Grand Vallon—Tafferau (see plan) afforded by the data of the Royal Engineering Staff, and which, though not belonging to a triangle of the first order is tied directly to one. (See Plate, 252.

The length of this side is 28,544·93 feet, and one of its extremities is at a little distance from the principal observatory of the Grand Vallon, while the other, elevated 9,184 feet above the level of the sea, is the vertex of that mountain which, on the left of the Dora, overlooks the two valleys of Oulx and Bardonnèche; it is well also to mention that the distance between the opening and the observatory of Bardonnèche was measured direct, and it was found to be 465·97 feet.

The whole of the trigonometrical system may be divided into two systems of triangles; the first includes the base and those triangles which extend to the south of the principal chain, and the second includes the triangles on the opposite side, leaving the two systems bound together by having one side in common, the extreme points of which are on the top of the same chain.

In order to specify more precisely this division of the trigonometrical system, we will briefly enumerate the order of the principal triangles, by means of which the measure of the total length of the tunnel was obtained.

System I. In this system connected directly to the base of the engineering staff survey by means of the triangles (see Plate 252.)

Grand Vallon, Tafferau, Trois Croix.
La Lauzat, Trois Croix, Tafferau

was obtained the length of the side,

Trois Croix, Tafferau

using this, and the triangles

Trois Croix, Tafferau, Observatory
Trois Croix, Observatory, Beauvoir,

was obtained the distance

Observatory, Beauvoir

and by means of the triangles

Trois Croix, Banda, Beauvoir
Prapinat, Banda, Beauvoir
Prapinat, South Observatory, Beauvoir

was obtained the length of the side

South Observatory, Beauvoir

the distance of which, deducted from the preceding

Observatory, Beauvoir

gave the length of the line

South Observatory, Beauvoir

the distance

South Observatory, south opening

measured direct, and deducted from the

South Observatory, Observatory,

gave the entrance, south observatory.

To fix the side which was to unite the first and second systems, operations were begun with the triangle

Trois Croix, Tafferau, Pelouse,

to find the side

Trois Croix, Pelouse,

and afterwards with the other triangle

Trois Croix, Pelouse, Punta di Frejus,

was ascertained the side

Punta di Frejus, Pelouse.

This same length was also fixed on the southern side, with the help of the triangles,

Belle-Côte, Trois Croix, Tafferau,
Belle-Côte, Tafferau, Pelouse
Belle-Côte, Punta di Frejus, Pelouse

which gave

Punta di Frejus, Pelouse.

In addition it was verified by means of the triangles

Tafferau, Chatrière, Pelouse
Chatrière, Punta di Frejus, Pelouse.

System II. This system had for its base the line Punta di Frejus, Pelouse, which ties it to the first system. It was begun by means of the triangles,

Punta di Frejus, Pelouse, Mont Rond,
Punta di Frejus, Mont Rond, Pietra Bianca
Mont Rond, Observatory, Pietra Bianca

so as to fix the side

Observatory, Pietra Bianca

The same distance was also obtained with the following triangles

Punta di Frejus, Mont Rond, Erplane
Mont Rond, Erplane, Observatory
Erplane, Observatory, Pietra Bianca

Having thus found the side

Observatory, Pietra Bianca

so as to have the distance

Opening, Observatory

which had to be added to the preceding ones, found out by the first system, it was necessary to deduct the length

Entrance, Pietra Bianca

The following are the triangles by which it was obtained

Erplane, Pietra Bianca, Les Aysards,
Les Aysards, Fourneaux, Pietra Bianca,
Fourneaux, Pietra Bianca, Entrance.

We have only considered the principal triangles; we must note however that the whole system consisted of 28 triangles, and 86 is the complete number of measured angles, all of which were repeated 10 times, for the most part 20 times, and the most important 60 times. As regards the instrument with which the angles were measured, a Gambey's theodolite was employed, the vernier of which gave at the first reading 5″ of approximation. As regards the exactness of the operations mentioned above, we may observe that the frequent cases of verification which occurred while the triangles were being traced out, and which from different points gave the same results, had diminished the chance of error to such an extent that there was no room for doubt as to the final result. And even if an error had been committed, which might have caused an alteration of 14 or 18 feet in the whole length of the tunnel, the modification that would have been involved by this difference in length, in laying out its gradients, would have been almost imperceptible, and no danger would have arisen through it, so far as regards the meeting of the two sections of the tunnel excavated from each end.

The operations of levelling were performed with very exact instruments. The level path passed Mont Frejus, which is the mountain nearest to the tracing, and it was laid out with numerous fixed points (one at each 164 feet of elevation) arranged to assist in checking the work, to limit errors, and to facilitate their discovery. As already stated, this levelling was done, and afterwards repeated by Mr. Mondino in the autumn of 1857, and again in 1858, the repetition giving a difference in the whole length of only 3·93 in. Afterwards Mr. Termine again checked the work, and reduced the error to only 1·574 in. The fixed points afforded the advantage of ascertaining whether perfect accuracy existed at each step, and in case of a difference it was only necessary to repeat the levelling between the two points where the difference occurred.

The Mont Cenis tunnel unites two points on the opposite sides of Mont Frejus, the position of which are such as to necessitate the two ends of the great work being formed on a curve. This circumstance however was not taken into account at first, and temporary entrances were opened on both sides of the mountain, in order to have the whole axis of the gallery in a straight line, and thus diminish the chance of error; in order also to obtain ventilation, and above all the transmission of motive power to facilitate the working of the mechanical boring appliances. The preliminary measurement gave a length of 13,861·5 yards between the two temporary headings.

It was necessary to construct the tunnel with two gradients, both rising from the entrances and meeting with a summit level at an intermediate point of its length. This was decided upon as well to provide an easy means of getting rid of the water, as to increase the chances of making a fair meeting

with the two headings. From the Bardonnèche entrance, 4408·50 ft. above the sea, the calculation gave a gradient of 1 in 2,000 for a distance of 20,997·33 ft. From the Fourneaux entrance, 3,945 ft. above the sea, the rising gradient was 1 in 43·4782 for 20,587 feet.

Elevation above sea level at Bardonnèche - -	4408·58	feet.
Rise of gradient of 1 in 2,000 for 20,997·33 ft -	10·49	„
Summit level - -	4418·99	„
Elevation above sea level at Fourneaux end - -	3945·00	„
Rise of gradient of 1 in 43·4782 for 20,587 ft. -	473·50	„
Summit level - -	4418·50	„

Thus far the figures based upon the data have been found by calculation. The actual figures, however, differ somewhat from these, the variations having proceeded from small discrepancies that were discovered while the final line of the tunnel was being traced, as well as from errors made in the precise levels of the stationary points.

The absolute figures are as follows :

Total length of the tunnel - - - - - -	13,364·86	yards.
Elevation above the sea level of the Bardonnèche entrance - - - - - - - - - -	4381·25	feet.
Rise of gradient 1 in 2000 for 20,048·10 ft. - -	10·24	„
Summit level - -	4391·274	„
Elevation above sea level at Fourneaux entrance -	3946·50	„
Rise of gradient of 1 in 45·045 for 20,0045·10 ft. -	445·00	„
Summit level from Fourneaux end - -	4391·50	„

showing a slight difference from the calculation of the summit level as reckoned at Bardonnèche, and giving a mean level for the highest point of 4391·386 ft.

To complete these data we may add that the vertical plane of the tunnel forms an angle of 19°, with the terrestrial meridian, and that the greatest height of the mass of the mountain over the tunnel is 5,307 ft.

From the foregoing it will be easily understood that the surveying operations, though not presenting extraordinary difficulties, were by no means easy on account of the local and atmospheric conditions, to say nothing of the necessary daily ascents and descents of 2,500 or 3,000 ft., the rapid and successive changes in the temperature, of fog, snow, wind, and sun, which often rendered work impossible, for it rarely happened, on account of the inclemency of the climate, that more than two consecutive angles could be measured, and many times not even one could be observed. This explains the long time taken up by the field work.

We may now proceed to consider the method used for maintaining the direct line of the axis of the tunnel while the work of excavation was being carried on. The observatories, B and T (see Plate 252), placed at the entrances of the tunnel, were used for the necessary observations, and both of the observatories contained an instrument constructed for the purpose. This instrument was placed on a pedestal of masonry, the top of which was covered with a horizontal slab of marble, having engraved upon its surface two intersecting lines marking a point, which was exactly in the vertical plane containing the axis of the tunnel. The instrument was formed with two supports, fixed on a tripod, having a delicate screw adjustment. The telescope was similar to that of a theodolite, provided with cross webs, and strongly illuminated by the light from a lantern concentrated by a lens, and projected upon the cross webs. In using this instrument in checking the axis of the gallery at the northern entrance, for example, after having proved precisely, that the vertical plane, corresponding with the point of intersection

of the lines upon the slab also passed through the centre of the instrument, a visual line was then conveyed to the station at Lachalle (F), and on the instrument being lowered, the required number of points could be fixed in the axis of the tunnel.

In executing such an operation it was necessary that the tunnel should be free from smoke or vapour. The point of collimation was a plummet suspended from the roof of the tunnel by means of an iron rectangular frame in one side of which a number of notches were cut, and the plummet was shifted from notch to notch, in accordance with the signals of the operator at the observatory. These signals were given to the man whose business it was to adjust the plummet by means of a telegraph or a horn. The former was found invaluable throughout all these operations.

At the Bardonnèche entrance the instrument employed in setting out the axis of the tunnel was similar to the one already described, with the exception that it was mounted on a little carriage, resting on vertical columns that were erected at distances 500 metres apart in the axis of the tunnel. By the help of the carriage the theodolite was placed first on the centre line approximately; it was then brought exactly into line by a fine adjusting screw, which moved the the eye-piece without shifting the carriage. In order to understand more clearly the method of operating the instrument, the mode of proceeding may be described. In setting out a prolongation of the centre line of the tunnel the instrument was placed on the last column but one; a light was stationed upon the last column, and exactly in its centre, and 500 metres ahead a trestle frame was placed across the tunnel. Upon the horizontal bar of this trestle several notches were cut, against which a light was placed and fixed with proper adjusting screws. The observer standing at the instrument caused the light to move upon the trestle frame until it was brought into an exact line with the instrument and the first light, and then the centre of the light was projected with a plummet on to the ground, and in this way the exact centre was found.

By a repetition of similar operations the vertical plane containing the axis of the tunnel was laid out by a series of plummet lines. During the intervals of time that elapsed between consecutive operations with the instrument, the plummets were found to be sufficient for maintaining the direction in making the excavation.

To maintain the proper gradients in the tunnel it was necessary at intervals to establish fixed levels, deducing them by direct levelling from standard bench marks placed at short distances from the entrances. The fixed level marks in the inside of the tunnel are made upon stone pillars placed at intervals of 25 metres, and to these were referred the various points in setting out the gradients.

Before considering the mineralogical and geological formation of that portion of the Alps separating Bardonnèche from Modane, it may be interesting to devote a short space to a series of the geological characteristics of the Alps in general.

The Mont Schiavo forms the beginning of the Italian Alps, on the Mediterranean side, and they terminate with Mont Bittoray at the Adriatic, not far from the city of Fiume. The ridge extends in a curve, about 955 miles in length, taken along the peaks of the chain. This great circle of mountains surrounding Northern Italy bears very different aspects on its inner and its outer faces. If we start from the highest peak of the Alps and descend on the outer side, we find a large continuation of ascents and descents, with comparatively easy slopes, whereas on the inner faces the plains are reached by a series of very abrupt spurs. Thus, for instance, Mont Blanc the highest peak of the Alps offers an easy ascent from Savoy, while on the Italian side it rises almost perpendicularly to a vast height above the valley of Aosta. So also, while the river Po, at Saluzzio, falls 5,249 ft. in a distance of 21 miles, the Rhine in descending from the same height, runs as far as Lake Constance, a distance of 92 miles.

It may be assumed that the whole Alpine chain is bounded by a line, drawn at the foot of the mountains through Mondovi, Sallizzo, Pinerolo, Ivrea, Biella, Como, Bergamo, Brescia, Peschiera, Udine, Trieste, and Pola, and

beyond Italy by another line, which beginning at Mondovi crossses Mont Schiavo to Abenga, as far as Nice, and thence passes by Entreveaux, Seyne, Geneva, Villeneuve, Altorf, Innsbrük, and Laïbach, thence, crossing the top of the Bittoray, it reaches Pola, and completes the enclosing line.

The Italian Alps form a series of clusters or heads, the principal of which are seven in number, and these have been named from the mountain that has the greatest number of spurs, and not from the one most conspicuous in height.

They are:

1. The group of the Stura and of the four Bishopries.
2. The group of Bardonecchia or of the Tabor.
3. The group of the Isera or of Mont Iseran.
4. The group of Mont Blanc.
5. The group of Mont Saint Gothard.
6. The group of Malaggio.
7. The group of the Pizzo dei tre Signori.

The group of Bardonnecchia is situated north of the sources of the torrent Dora Riparia, and it extends from Mont Cenis to Mont Ginevro, giving birth to the two principal branches of the Dora, one of which springs from Mont Ginevro, while the other descends from the top of the Great Miol, and is at first known as the Ripa, and afterwards the Dora Riparia.

The idea of opening the tunnel through the Alps with the object of facilitating the communication between England and France is due to M. Médail, a native of Bardonnèche. This gentleman, whose pursuits led him frequently across the mountains that surrounded his native village, ascertained the way in which, from the valley of the Arc—at whose head is Modane, at the foot of the western side of Mont Frejus—it was possible to descend to the banks of the Rhone, by continually skirting the torrent of the Arc without any rapid gradients, by keeping always on the sides of the high spurs to the right and left. The same facilities seemed to be offered by nature for the construction of a railway from Bardonnèche to Susa. The only obstacle in uniting France and Italy was therefore the construction of a tunnel under Mont Frejus, so as to join Bardonnèche and Modane. This point of crossing was the only one that could be selected, involving a tunnel of no greater length than the one that has been constructed. In 1841 M. Médail published a pamphlet at Lyons upon this subject. The work, however, obtained no attention, and the author died without the satisfaction of seeing even the first steps taken in the matter which he had advocated.

When the construction of the Mont Cenis tunnel was first discussed as a practicable and probable scheme, the popular notions as to the geological difficulties that would be encountered were as numerous as they were original, and were equalled by the prejudices that arose on all sides, springing even from high scientific sources. To investigate the validity of the opposition coming from responsible persons, the Sardinian Government requested Professor Angelo Sisimunda to report fully upon the prospects of the work. We shall here only briefly allude to the results of his labours, which were presented in due course to the Secretary of State for Public Works.

Professor Sisimunda found the distribution of rocks between Bardonnèche and Modane to be as follows:—Arenaceous, micaceous, and schistous united together—quartzites—chalk (internally anhydrite) with limestone and sometimes with dolomites, and lastly crystalline schistous lime, alternating with argillaceous and decomposed schists.

Professor Sisimunda divided these rocks into three groups, and named them as follows:—

1. Superior group. Anthracite, which includes the micaceous arevania, with schists and quartzites.

2. Group represented by oolite, and including the lime and chalk. This group is, according to the report, a continuation of the great stratum of the some nature near Villette, in Tarantasia.

3. Inferior group. Anthracite and schistous lime, with metamorphic and argillaceous schists.

It is easy to prove a discordance in the stratification between the schistous

lime of the inferior anthraciferous system and silicious lime, the chalk and dolomite representing the superior lias formation, and the inferior oolite. This fact is almost universal in the Alpine chain, and is caused by a constant undulation in the rocks. The irregularity of stratification between the silicious lime and the layer of quartzite that is above it, and which is almost vertical, might be the effect of the ruption which has taken place, and which runs across the Alps in a direction from south to north. The displacement of the rocks having taken place in the direction of the depth of the formation, the succession of the strata would not, according to Professor Sisimunda, have undergone any change from the ruption.

The plan and section of Mont Frejus on Plate 252 show the position of the different strata to which we have referred. In order to give an idea of the dimensions of the strata, it may be remarked that their widths vary on the outer surface and within the mountain; the following table of inner and outer profiles gives the exact figures:—

On the Surface.

	ft.	in.
Anthraciferous rocks—width of stratum	5,814	3
Quartzites	1,761	9
Compact limestone and dolomites	1,004	0
Schistous limestone	31,512	4

Inside and along the Tunnel.

Anthraciferous rocks—width of stratum	6,879	3
Quartzites	1,274	6
Compact limestone and dolomites	1,166	8
Schistous limestone	30,774	2

Upon the surface on the Bardonnèche side the schistous limestone has an average dip varying between 20° and 25° to the west, and from 40° to 45° on the west, increasing at the Col de Frejus to as much as 50°. The chalk is so distorted that the stratification is not recognizable. The quartzites are nearly vertical at the commencement of the stratum; they incline towards the south-west at an angle varying from 90° to 65°. The anthraciferous sandstone inclines in some parts towards the north-west, at others to the south-east, and at the extreme point it is nearly vertical.

Inside the mountain along the tunnel the schistous limestone inclines from north-west to east at an angle varying from 5° to 10°. The chalk stratum is also here indistinguishable. The quartzites incline to the north-east at varying angles between 50° and 60°, then it becomes vertical. The anthraciferous sandstone dips from north-west to east, with angles of from 50° to 80°.

In the course of the tunnel excavation on the Modane side, frequent changes were observed in the degrees of the inclination of the rocks, but the general direction of this inclination always tended towards the west; it was also observed that before reaching the quartzites, the strata made a curve resembling the letter C with the convex parts turned eastwards.

In the tunnel quartzite was met with about 295 ft. east of the spot that was anticipated by Professor Sisimunda in his report presented to the Government in 1845.

The direction of the tunnel is nearly north 14° west, and the axis strikes the strata at angles varying from 34° to 40°.

As regards the different degrees of density of the rocks that compose the three different groups, of course the quartzites were the hardest and the schistous limestone the softest. But as regards the facility of excavation by mechanical means, all miners know that homogeneous rocks are more convenient to excavate than others which are variable in quality, soft in some places, and mixed with quartzites in others. The quartzites on the Modane side presented such an extraordinary degree of hardness that steel and percussion seemed to have no effect upon them, and several hundreds of steel chisels (as we shall hereafter see) have been worn out daily to make a few

insignificant holes, notwithstanding the enormous mechanical appliances employed. The quartzites were indeed at times as hard as regular quartz crystals, translucent, and sometimes slightly coloured like amethyst. We shall see further on how great the efforts were that had to be employed to pierce through the wall which nature appeared to have erected to bar the daring undertaking. It was ascertained with certainty that the rocks were less hard on the line of tunnel than on the surface of the mountain; the difference may be chiefly attributed to the action of the atmosphere upon the latter. The frequent changes in the long series of schistous limestone has to be attributed to metamorphic action. As this stratum is the predominating one, we shall give some particulars as to its nature. Starting from the south opening, the aspect changes in the following manner:—

At 1,640 ft. it was granulous limestone, grey, hard, uniform in colour, with splits in regular layers.
At 4,880 ft. it was black limestone, hard and laminating.
At 5,570 ft. the limestone was coloured with oxides, and presented the appearance of eufotide.
From 6,161 ft. to 6,286 ft. very hard limestone.
At 7,020 ft. very hard limestone, grey, and veined with white granules.
At 8,202 ft. schistous limestone, black, with signs of graphite.
At 9,840 ft. the same, but splitting in layers.
At 13,097 ft. schistous limestone, not so compact, with graphite.
At 13,123 ft. very hard black limestone, granulous, like granite.
At 14,960 ft. very black limestone, with hornblende, but not very hard.
At 15,380 ft. black limestone, mixed with graphite and albite.
At 19,000 ft. white limestone, a little crystallised.
At 19,284 ft. black limestone, not hard, combined with layers of very hard white limestone.

These particulars, together with the plans and sections upon Plate 252, will, we hope, give clear and detailed information upon the geological character of the Alps along the axis of the tunnel.

The ground lying between the torrent of Rochemolles and the village of that name, being on a slight and regular incline, was chosen as the site for the principal workshops, including the repair shops, the buildings for the air compressors, the dwelling-houses for the engineer, clerks, workmen, &c. In order to secure good communication between these large workshops and the head of the tunnel, a road was built along the side of the Rochemolles torrent 6,400 ft. in length. In front of the head of the tunnel, on the top of an embankment, mostly composed of rock excavated from the workings, smaller shops were established for those purposes which more closely appertained to the actual work of excavation, such as sheds for mortar mills, carpenters' shops, and repair shops, for making small alterations, and for doing general jobs to the boring machines, smiths' forges, &c.

At the commencement of the excavation, brick yards were also established, but they were afterwards abandoned, the bricks being provided by contract, and transported from Oulx, where they were manufactured.

On the road leading to these secondary shops, and at some distance from any habitation, was located the chief powder magazine, which contained usually more than 25,000 lb. of powder, and from which, for the sake of safety, the necessary supplies for two or three days were periodically removed, and placed under a shed not very far from the opening of the tunnel, near the shops where the mining cartridges were fabricated. The number of workmen employed in these establishments varied a good deal, the numbers being greater or less, according to the speed with which the excavation proceeded. But the average number engaged in the shops and in the tunnel was 1500, besides 300 more employed in getting stone from the adjacent quarries, and some 200 bricklayers employed by private contractors, so that in all the number of men employed in and about the works at the Italian end was about 2,000, not inclusive of those engaged upon transport.

The workmen within the tunnel worked in eight hour shifts, and thus three times in every 24 hours, that is to say at midnight, at 8 a.m., and at 4 p.m., they were changed; those on the contrary working at the headings had no

fixed hours, only changing when each set of men had finished their task of longer or shorter duration, according to the difficulties encountered; the workmen in the shop made on the average 10 hours' work daily.

The water used for driving the different machines was brought from the torrent of Meleget, near the village of Les Armand, along a fine aqueduct in cut stone, and thence through a system of sluices it passed into the channel conveying it to the shop. This channel is built in brickwork, and averages 3 ft. 11 in. in breadth, having a capacity of a cube metre per metre of length; it is covered in some places with a brick arch, in others with stone flags; for some distance it skirts the torrent, then turns, and follows the side of the mountains, underneath various torrents, until it crosses the Mefdoune, by means of an aqueduct, after a course of nearly two miles. The waters of the Meleget, after heavy rain and thaws, are sometimes very muddy, and full of sticks and leaves, small roots, straw, and other débris, that would interfere with the action of the compressors first employed; in order to prevent any serious inconvenience a large settling reservoir was made near Bardonnèche, and about two-thirds of the distance from the commencement of the conduit. The water rushing into this reservoir with a great rapidity, attained by the fall of the channel, spreads itself, losing its velocity instantly, depositing at the bottom the substance of the greatest specific gravity, whilst the lighter ones, floating onwards, were stopped at the outfall of the reservoirs by movable gratings.

On entering the principal yard of the Bardonnèche road, one saw on the right hand a plain building containing the offices. Near this is the mouth of the tunnel, which is made to connect the great tunnel with the Bussoleno-Bardonnèche line. The length of this connecting tunnel is 820 ft. Opposite the offices stood the dwelling-houses of the employès, and contained a club. Behind it are the wooden store shed, washing house, and infirmary, and not far off are small gas works, and a gas holder standing within a close circular shed. These works which now only supply gas for lighting up different parts of the yard, were at first intended to make the gas with which it was proposed to light the interior of the tunnel as the work proceeded; but this was found to be attended with great inconvenience, for when blasts were made, the expansion of the air extinguished the gas, and the workmen very often found themselves in perfect darkness, which besides causing confusion and loss of time, permitted the free escape of gas which further vitiated the air, impure already from the explosion of the powder, and the exhalations of the workmen.

Along the banks of the torrent of Rochemolles are the dwelling-houses of the workmen, which are protected against floods by an embankment formed with the rock excavated from the tunnel. The unmarried men had one room awarded to four, the married men lived in separate houses, and each having a room. In the centre of the yard is a spacious court, round which are ranged the repair shops, the compressor buildings, and a school house for the workmen's children, and containing the apartments of the masters and mistresses, and a provision store. Opposite this building are two large reservoirs for compressed air, the use of which which will be explained hereafter.

The shops for repairing the boring tools, and other machinery, contained every necessary for the purpose, such as lathes, planing machines, drilling machines, shaping machines, &c., besides the smiths' forges and air-driven hammers. The whole of the machinery with this last exception was driven by a 12-horse power wheel. A shop thoroughly well suited for these repairs was absolutely necessary in order that the constantly recurring alterations and repairs required by the perforators, should be done without any delay. The rapid destruction of their tools was due principally to the injurious action of the quartz dust, cut away by them, but also by the violent shocks which they constantly received when at work.

Near the repair shops, and occupying one side of the court-yard, were the compressor houses. The one first completed, containing the water column compressor, was a large covered building, with large windows, and enclosing 10 of these important machines, which however were, after a short trial, abandoned. Nevertheless, they are worthy of description, for they first led

to the idea of mechanical perforation, which has been attended with so abundant a success. As regards these compressors, we must note that the different heights, hereafter mentioned, refer to a horizontal plane, which we will call the effluent level, because it contains that height at which the water stands in the compression chamber when it is full of the air, that is to receive the descending stroke of the compressing column.

If we suppose the spectator standing on this plane, opposite to the compressor buildings on the right and left, he would see before him 10 compressors, all of equal dimensions, and divided into two groups of five each; between the two groups are two motors, actuated by the compressed air, each of which works a horizontal rod, opening and closing at regular intervals the supply and exhaust valves of the compressors. We may call this the principal valve motion. Each group of compressors was independent of the other, and has its motor and principal valve motion, but by a very simple arrangement both groups may be worked together, while, if when they are at work it happens that some of them may become impaired, they may be isolated without interfering with the rest.

For the special class of work to which they were adapted these precautions were absolutely necessary, so that under any circumstances a sufficient quantity of air may be secured in order to prevent any stoppage in the boring operations. In front of each of the compressors there is placed an iron receiver with spherical ends, into which the compressed air is delivered at every stroke of the same column of water that effects the compression. These receivers are made abundantly strong. They are all placed in communication with each other by means of a pipe, so that they all operate together, if desired, but may be divided into groups of any number, as may be expedient. By this arrangement the amount of power can be regulated, and repairs effected without causing any delay. The contents of each of the receivers is 600 cubic feet, and in order to ascertain exactly the quantity of air produced or consumed, each receiver was tested by fixed quantities of water being poured in, and the heights of the corresponding levels were marked on a scale outside; in this way the graduations to 3·5 cubic feet were fixed. At 85 ft. 3 in. above the effluent level is the great reservoir, in which the compressing columns unite. These 85 ft. 3 in. mark the height or stroke of the column of compression so soon as it begins to come into action. Inside the reservoir the columns are made with a funnel-shaped top, so as to avoid the effects of the contraction of the water in its flow, and each is provided with a cover, so that the water can be excluded, and the corresponding compressor emptied, and submitted to repairs when desired. The water is led into the reservoir by large iron mains, which lead it from the conduit 65 ft. 7 in. above. These mains are, of course, fitted with all the necessary valves, sluices, &c., for keeping the water under control. At a point still more elevated, 164 ft. above the plane of efflux, on the hill side, is the regulating reservoir, having a capacity equal to upwards of 14,000 cubic feet, built in brickwork, and roofed over, the covering being supported on pillars, and earth being placed above for a depth of 3 ft. 3 in. to protect the water from the action of frost. From this reservoir two iron pipes are taken, each communicating with one of the two groups of receivers before mentioned, both groups being connected to the pipe that draws water from the regulating reservoir, and the columns of water contained in these pipes for their height of 164 ft. maintain almost invariably the pressure of air on the receivers. As regards the regulating column the receivers are put in action by means of appropriate valves, together or separately, so that in this detail also they work together or separately, as may be desired.

It was soon found, however, that these compressors became damaged by the violent shocks the valve had to resist, when they were suddenly closed, and hence their use has been abandoned, the simple machines known as the "water-spout" compressors, were found to be more reliable, so that all the compressed air has been produced by these machines. The water-spout compressors at work in the yard, were actuated by seven water wheels; the quantity of water used was small, only 35·317 cubic feet per second, but it has a considerable fall of 144 ft. The wheels were placed one below the other, so

that the waste canal of one formed the supply canal of the other, and thus all the fall was utilised by giving 19 ft. 8 in. of fall to each wheel. The wheels were placed in separate buildings; the three lower ones arranged back to back. A description of one will suffice for all. An iron wheel, 19 ft. 8 in. in diameter and 16 ft. 4 in. wide, gives motion from the shaft on which it is mounted to two heavy connecting rods, actuating two pistons. On each side of the wheel, stand coupled together two large cast-iron cylinders, vertical, but turned round at right angles at the floor level so as to form horizontal cylinders in which the pistons before mentioned work slowly, their alternate motion being communicated to a water column which rising and falling alternately in the vertical part of the cylinders, compresses the air which is admitted into, and forced from the cylinder by means of a set of ordinary inlet and outlet valves.

An iron staircase led to a gallery from which the upper part of the machinery may be examined. Everything worked with the utmost precision, the motion was perfectly regular and free from shock, so that these machines worked constantly for years without requiring repairs. The compressed air was passed into the receivers before mentioned, by a collecting pipe communicating with all the compressors. Up to 1864 these receivers were the only reservoirs for the compressed air, but they were insufficient for the quantity required, especially when any short delay took place in maintaining the supply. It became necessary, therefore, to construct other reservoirs, and two wrought-iron receivers, 164 ft. long and 6 ft. 6 in. diameter, were made and now stand under the school house and provision store.

When these were made, the regulating reservoir became insufficient, and therefore it would have been necessary to construct a much larger one; but this great expense was avoided by regulating the pressure in the following manner: The consumption of the compressed air, or the working of the perforators was intermittent; during the time of work the consumption was equal to the quantity produced, but in the time of stoppages, the air passed from the compressors into the reservoir, and increased the pressure in them; when this reached six atmospheres, a safety valve in the main, that carried the air along the tunnel, opened, and the air that escaped through it was carried by a tube to ventilate the farthest headings, and this was a very necessary precaution, because, when the mines were exploded, the dense smoke caused by the combustion of the powder rendered the workings untenable. So soon as the boring machines were put into work again, the pressure of course fell, and the safety valve closed. In this manner the pressure was regulated well, and with economy.

The large main that conducted the compressed air to the extreme limits of the heading was laid along the road, resting on brick pillars, for a length of 6,400 ft., to the opening of the tunnel. This main was exposed to all the inclemency of the climate of Bardonnèche, and to variations of temperature ranging from 15° of frost to 104° in the sun. But these violent extremes had no serious effect upon it, although during winter a part of the main was always covered with snow. The tube is 7·84 in. inside diameter, it is ·39 in. thick, and is made in lengths of 6 to 8 ft. These were cast with special care, and the joints are made good with compressed gutta percha.

We may now say a few words about the shops at the entrance of the tunnel. Here were located the forges for repairing and sharpening the boring tools, the blast being obtained from a fan worked by a 10-horse water wheel. There were also workshops to repair the less important damages sustained by the drills, and which saved the trouble of their being removed to the main shops already described. Here, also, was a dwelling-house for the mechanics. Further on is an observatory—a small hexagonal tower, marking the line which passes though the centre of the tunnel, in the centre of which, and standing on a strong foundation, is a theodolite. At the entrance of the yard is the clerk's house, with the offices, and provision stores, general store, stables, &c. A long shed serves for the carpenters' shops and wagon shelters.

The mortar mills were also here, and near them a small machine for making clay tamps for the blasts; the clay was forced through orifices of the desired

size, and was cut off into lengths with wires, and dried. A large ventilator placed over the tunnel entrance drew through a wooden conduit, fixed to the roof of the excavation, the external air replacing it as it was exhausted. This fan was driven by the same wheel that actuated the forge fan; it moved in a horizontal plane, was 19 ft. 8 in. in diameter, and was enclosed within a covered shed.

Originally the draught was produced by heated air from an upcast shaft, and though this arrangement answered when the borings had reached no great depth, it became of course entirely inefficient as the work advanced.

Having given a general idea of the disposition of the external works and workshops at Bardonnèche, we need not describe those at Modane which were similar in their principal parts. There was only one essential difference between the two arising from the difference in the local conditions: At Bardonnèche the opening of the tunnel is at the same level (or nearly) as the workshops, whereas, at Modane, it is at a considerable height above them. An inclined plane was therefore established at Modane, on which everything was conveyed up to the mouth of the tunnel from the workshops and working yards down below.

The motive power in working this inclined plane was the weight of a mass of water confined in receivers adapted for the purpose, which travel up and down the incline, and pull up with their weight (properly regulated by the admission of a greater or smaller quantity of water) the cars loaded with the materials, tools, and implements, &c., required for the tunnelling.

The mechanical appliances employed in the Mount Cenis Tunnel consisted of two separate parts,

1. The plant outside the tunnel.
2. The mechanical means employed in the tunnel for the excavation of the rock itself.

The former may be subdivided into—

(*a.*) Ventilation.

(*b.*) Transmission of motive power.

The latter consists of—

(*a.*) The perforation by the machinery invented by M. Sommeiller, of the holes for blasting.

(*b.*) Blasting.

(*c.*) Clearing away of the excavated rock.

The requirement of special ventilation and of special excavating appliances, as well as the absolute necessity of a particular kind of motive power, is self-evident when the length of the Mont Cenis Tunnel is taken into consideration.

All who ever have carried on mining are aware of the importance and difficulty of ventilation, when the length of the tunnel becomes excessive. It may be interesting to offer a few remarks on this subject, having a special reference to the means employed in the work we are now describing.

The causes of the vitiation of air in tunnels are the blasting of the mines and consequent explosion of gunpowder, the combustion of tamps and the respiration of the workmen.

One pound of gunpowder exploding produces

0·49 lb. carbonic acid gas
0·10 „ oxygen
0·41 „ sulphide of potash

Now, as atmospheric air fit for respiration only can contain about 5 per cent. of carbonic acid gas, the explosion of one pound of gunpowder is capable of vitiating $\frac{0\cdot49}{0\cdot005}$ lb., that is 100 lb. of air, or speaking in volume instead of weight, 45 cubic yards of air, one cube yard of air weighing in round numbers 2·18 lb.

However, the carbonic acid is not the only gas produced calculated to render air unfit for respiration.

The proportion of oxygen in the air is nearly permanent, being 79 per cent., and if this percentage is increased air becomes unfit for breathing.

Further, sulphide of potash considerably vitiates air, and hence we may safely admit that 1 lb. of burnt gunpowder impregnates 148½ cubic yards of air.

Now practice has shown that in order to render air fit for respiration in a place where there is no current, from 10 to 13 cubic yards of fresh air per hour have to be introduced for every man employed.

Further, to replace the air consumed by the combustion of each miner's lamp, about 9 cubic yards of air are wanted per hour.

Let us now consider the quantity of air which would have to be consumed for 130 cubic yards of excavated material, excavation being carried on with ordinary means. Practice has shown that in order to excavate 130 cubic yards of hard rock, 400 blasts are required, and 176 lb. of gunpowder are consumed; further, to make 400 blasts 214 days' work are required, calculating a day's work as 12 hours; and, again, as in a gallery, masons, carpenters, &c., are wanted, we may add 120 days' work of 12 hours each.

Supposing, then, that 130 cubic yards of rock should be extracted in 24 hours; during this period of time we shall have to introduce:

	cubic yards.
For 107 miners, and 60 other workmen - - - -	52,424
About 83 oil lamps - - - - - - -	18,238
To replace the air vitiated by the explosion of 176 lb. of gunpowder - - - - - - - - - -	26,160
	96,822

For every 130 cubic yards of rock extracted 96,822 cubic yards of fresh air is required.

Now the section of the Tunnel of the Alps having 71¾ square yards, in order to advance *one* yard in length in the excavation, if ordinary means were used, about 53,400 cube yards of air would be consumed, and as the total length of the tunnel is 13,364 yards, to perforate it entirely over 710,000,000 cubic yards of air would be consumed.

Further, the temperature of air must be kept within certain limits to maintain the workmen in a proper condition.

We know that approximately for every 98 ft. of depth attained from the surface of the earth temperature increases 1·80°. The height of the mountain under which the Mont Cenis Tunnel passes being 5,285 ft., the temperature in the tunnel would be 127·40°, to which we should further add the temperature produced by the burning of gunpowder and the combustion of lamps, we may safely assume the temperature to be 140°.

These considerations will clearly show the absolute necessity of a very efficient system of ventilation being adopted, without which the execution of the work would have been utterly impossible; further, the ordinary means used by miners for ventilation were not sufficient, nor indeed were they applicable.

These ordinary means consist of fans which are placed at the mouth of the tunnel, which is divided into an upper and lower chamber, in order to allow the vitiated and more heated air to be drawn along the upper part, and to be replaced by pure air along the lower part of the gallery.

But in tunnels of such excessive length, not only hours, but days would be required before pure air would arrive to the headings, even were the causes of the vitiation of air not permanent.

Hence it was necessary to carry along with great velocity, and compassed in a small volume, a sufficient quantity of air precisely to those parts of the tunnel where the works were concentrated, and the permanent causes of the vitiation of the air existed; or, to speak more correctly, it was indispensable to combine the two means of ventilation.

The exhausting machinery at Bardonnèche consisted of a tangential turbine, moved by a column of water 65 ft. 7 in. in height. The theoretical velocity is 87 revolutions per minute, and about 40 cube yards of air can be extracted with it per second.

At Modane the exhausting machinery consisted of an ordinary pump. As regards the machinery with which compressed air was sent along to the

heading in the tunnel, they were the same as those with which the motive power was produced, and will be described presently; in fact, the introduction of compressed air in the heading was effected by opening cocks along the tubes which carried the motive power. There certainly was a great inconvenience in using compressed air in the ventilation, owing to the consequent loss of useful work. Let us form an idea of this loss by estimating the quantity of work which can be performed by a cubic metre of compressed air.

$\int p\,dv$ represents the work which gas produces in expansion. If we suppose that the gas in expanding absorbs so much heat from the surrounding gas that its temperature becomes equal to that of the latter, the equation of elasticity of the air will be $p\,v = \mathrm{R}\,t = \cos t$, and hence,

$$\int p\,dv = \int \mathrm{R}\,t\frac{dv}{v} = \mathrm{R}\,t\int\frac{dv}{v} =$$

$$\mathrm{R}\,t\ \text{hyp. log}\ v + \cos t,$$

will express the work done by the gas through expansion.

And as its temperature remains constant, Mariotte's law receives an application: the compressed air being supposed by us to expand from a pressure of six atmospheres to that of air, its volume from v_1 will pass to v_0, so that $v_0 = 6v_1$, and hence the work which the air through its expansion is capable of producing, will be given by the expression:

$$\int_{v_1}^{v_0} r\,dv = \mathrm{R}\,t\ \text{hyp. log}\ \frac{v_0}{v_0} = \mathrm{R}\,t\ \text{hyp. log}\ 6,$$

or passing from the Naperian to decimal logarithms,

$$\mathrm{R}\,t\ \log 6 \times 2{\cdot}30;$$

the constant for air is $\mathrm{R} = 29,27$.

The temperature, $t = \alpha + t_1 = 273 + t$, which we will suppose 300° centigrade, and completing the calculation we find 15,718 kilogrammetres as the result.

This calculation refers to 1 kilog. of compressed air, and 1 metre cube of air weighing 1·3 kilog., according to Mariotte's law, the cubic metre of compressed air expanding from the pressure of six atmospheres down to that of one atmosphere, its volume will become 6 metres cube or nearly, and the weight will be 7·80 kilog.; thus one metre cube of air compressed to six atmospheres, and expanding down to one atmosphere, developes useful work equivalent to 15,718 kilogrammetres × 7·8 = 122,600 kilogrammetres.

This quantity of work lost by the application of one metre cube of air compressed to six atmospheres for ventilation, is certainly enormous. However, the loss had to be submitted to, in order to make respiration, and continual work at the heading possible.

Allusion has just been made to the elevated temperature, and to the vitiation of the air in the tunnel. These two causes excluded the possibility of the use of steam-worked machinery. Had this motor been used, it ought to have been produced on the spot, because steam cannot be transmitted to considerable distances without condensing, and as for the production of steam, fire is wanted, the surrounding temperature would have been insupportable, and would, further, through the absorption of oxygen, have made the air totally unfit for respiration.

Further, work is synonymous with heat produced, and hence the work itself, done by the machinery, would have contributed to render the temperature unbearable, had not the heat developed been counteracted by the motive power itself, which produced the work. For all these reasons it was self-evident that if mechanical means were to be used (and the work could not be accomplished without them), the motive power of the machinery employed was to be produced outside the tunnel, and carried along in the tunnel to the very spot where machinery was to be applied.

This problem had but one solution, which consisted in the application of compressed air as a motive power. This solution seems self-evident at first sight, because the application of compressed air as a motor is not a new idea nor a new invention.

Father Hall, a Hungarian Jesuit, in the middle of the eighteenth century, by means of a waterfall, guided compressed air in a tube to a recipient, from which this compressed air, passing in a second chamber, raised and discharged the water in the mines of Selmecx (Schemnitz).

Further, we remember that Montgolfier invented the hydraulic ram, by which he utilised the *vis viva* gained by water in its fall. But the application of these ideas to the production of mechanical work for the Mont Cenis tunnelling had to meet with many objections, and great difficulties. The difficulties not only consisted in the invention of compressing machinery capable of compressing the immense quantity of air wanted; they also arose from doubts on the possibility of constructing large hermetically closed recipients, such as would not allow the digression of the air.

Experiments had to be made on this subject, and a recipient was erected at Bardonnèche. It was filled with air compressed to six atmospheres, and was left 24 days untouched. Fortunately, only a very small loss was detected as having taken place, which did not even amount to $\frac{1}{3000}$th part of the daily production.

It was objected that the transmission of compressed air to great distances, for the purpose of moving machinery, would hardly be possible, because of the loss of the pressure of the air produced by its friction along the conducting tube. This objection was considered a very serious one, as it was stated by great mathematicians, who made out apparently correct theories on the action of gases through long tubes. Further, several unsuccessful attempts had already been made to transmit compressed air, by Wilkenson and others.

It is true that Girard, and later, D'Aubuison and Marot, and again, the celebrated Ponceclet and Peclet were more successful in their experiments; they were not sufficiently so, however, to decide absolutely the case in favour of the possibility of the undertaking.

By order of the Italian Government, experiments were made on this subject, and more especially on the hydro-pneumatic compressor proposed by Messrs. Sommeiller and Grattoni. The results of these experiments may be summed up in the annexed Table.

Loss of Pressure in 1,093·6 Yards in Inches of Mercury.

			in.	in.	in.	in.	in.	in.
Diameter of the tubes -		-	$3\frac{15}{16}$	$5\frac{7}{8}$	$7\frac{7}{8}$	$9\frac{13}{16}$	$11\frac{13}{16}$	$13\frac{3}{4}$
Initial velocity per second.	ft.	in.						
	3	$3\frac{3}{8}$ -	$\frac{16}{64}$	$\frac{5}{32}$	$\frac{1}{8}$	$\frac{1}{8}$	$\frac{5}{64}$	$\frac{5}{64}$
	6	$6\frac{11}{16}$ -	$1\frac{1}{32}$	$\frac{45}{64}$	$\frac{33}{64}$	$\frac{7}{16}$	$\frac{23}{64}$	$\frac{5}{16}$
	9	$10\frac{1}{16}$ -	$2\frac{7}{16}$	$1\frac{11}{32}$	$1\frac{7}{32}$	$\frac{63}{64}$	$\frac{43}{64}$	$\frac{45}{64}$
	13	$1\frac{7}{16}$ -	$4\frac{1}{4}$	$2\frac{69}{64}$	$2\frac{1}{8}$	$1\frac{47}{64}$	$1\frac{27}{64}$	$1\frac{7}{32}$
	16	$4\frac{13}{16}$ -	$6\frac{37}{64}$	$4\frac{13}{32}$	$3\frac{5}{16}$	$2\frac{41}{64}$	$2\frac{13}{64}$	$1\frac{57}{64}$
	19	$8\frac{3}{16}$ -	$9\frac{11}{64}$	$6\frac{9}{64}$	$4\frac{39}{64}$	$3\frac{45}{64}$	$3\frac{5}{64}$	$2\frac{41}{64}$

From this Table we see that for a length of 7,108 yards, with tubes of $3\frac{15}{16}$ in. in diameter, supposing the original velocity per second to be 16 ft. $4\frac{13}{16}$ in., the loss of pressure at the end would only be $39\frac{11}{16}$ in., that is, about 1 and $\frac{1}{8}$ of an atmosphere. Putting the initial velocity only at 13 ft. $1\frac{7}{16}$ in., the loss of pressure would be reduced to $27\frac{5}{8}$ in. or $\frac{9}{10}$ of an atmosphere, and, if we suppose the tube to have 20 per cent. greater diameter the loss would still be reduced by the half of this latter loss.

The final results of the experiments alluded to above, are shown in the following Table:

Area of the Orifice.	Velocity per Second.				Gauge at the end of the Tube.	Loss of Pressure.	
	In the Tube.		When issuing.			Observed.	Deduced from the Curve of Interpolation.
sq. in.	ft.	in.	ft.	in.	in.	in.	in.
·0281	3	$3\frac{13}{16}$	488	10	$14\frac{7}{8}$	·1525	·1525
·0983	10	$5\frac{13}{16}$	473	$0\frac{7}{8}$	$14\frac{13}{16}$	2·0472	1·7656
·0983	11	$5\frac{7}{16}$	501	$11\frac{5}{8}$	$14\frac{59}{64}$	3·1093	2·125
·0983	11	$9\frac{13}{16}$	526	$10\frac{6}{8}$	15	2·7187	2·25
·0983	13	$5\frac{9}{16}$	600	$4\frac{3}{4}$	$14\frac{11}{16}$	2·3936	2·875
·1264	14	$5\frac{1}{2}$	495	1	$14\frac{7}{8}$	3·2677	3·344
·2776	33	$3\frac{7}{8}$	526	$2\frac{3}{4}$	$14\frac{63}{64}$	15·3906	15·2031
·4844	49	$6\frac{7}{8}$	448	2	$14\frac{3}{4}$	35·5468	35·5468
·7639	60	$6\frac{3}{8}$	347	6	$14\frac{9}{32}$	61·4218	61·4218

The preliminary results observed at Bardonnèche confirmed those obtained by the experiments we have alluded to. In the table given above we find that for a tube of $7\frac{7}{8}$ in. diameter, the air being compressed at 6 atmospheres, and the velocity being at the commencement $39\frac{3}{8}$ in. per second, the compressed air would lose for every 1093·6 yards, a part measured by a column of mercury of $\frac{1}{8}$ of an inch in height. Comparing this loss with the atmosphere, the loss would be represented by $\frac{8}{7000}$, or $\frac{1}{127}$ of an atmosphere for 1·24276 miles. Now when these tests were made at Bardonnèche the length of the tube conveying the compressed air was precisely this length. It had a diameter of $7\frac{7}{8}$ in.; the velocity of the air at the origin was 3 ft. $3\frac{3}{8}$ in. per second, and hence the volume of compressed air flowing out at the opening was 1·109 cubic feet. Nine perforating machines working together consumed ·9531 cubic feet every second, and the loss of pressure at the extremity of the tube was found a little inferior to $\frac{1}{127}$ part of an atmosphere; and hence the result deducted from the tables was confirmed by those practically obtained at Bardonnèche.

It may be interesting to give here a few theoretical observations on the movement of gas in tubes, nor will it be out of place, the subject being closely connected with the motive power which was used to carry out the perforation of the tunnel under the Alps. Besides, compressed air as a motive power, will no doubt receive very wide and important application in future, and hence mechanical and civil engineers cannot sufficiently study the questions which are connected with the important problem to the solution of which the possibility of the completion of the tunnel is owing.

Compressed air, and indeed almost all gases moving along a tube, encounters a certain amount of resistance owing to friction.* If we represent by L the length of the tube, and D its diameter, the loss of pressure occasioned by the friction alluded to, is represented by

$$H - h = K\frac{L}{D}\frac{v^2}{2g},$$

where H and h are the pressures at the beginning and the end of the tube measured in columns of the same gas, at the density it has at the section at which the velocity v is taken, and where K is a numerical coefficient (the coefficient of friction = 0·0236), and g is the accelerating force of gravity.

Let H_1, and H^1, and h be respectively the pressures in the reservoir at the starting, near the orifice of outflow, and externally, measured in columns of gas of the density of the gas in the reservoir, D and d being the diameter of the tube, and of the orifice by which the gas flows out; further, ϕ ψ, the coefficients of contraction at the entrance into the tube, and at the orifice of escapement, and K that of friction, as said above; v the initial velocity in the tube, $\alpha + t^1$ the absolute external temperature, and $\alpha + t$ the absolute temperature of the reservoir.

* Report of Signor G. B. Cravesana.

The general equation of the motion of the gas in a rectilinear tube of uniform section will be,

$$H - h = \frac{v^2}{2g}\left\{\left(\frac{1}{\varphi^2}-1\right)+K\frac{L}{D}+\frac{D^4 H(a+t^1)}{\psi^2 d^4 H^1 (a+t)}\right\}$$

To obtain the pressures measured in columns of mercury, if P_1 P^1 and p are the heights of mercury equivalent to H H^1 and h of gas; and δ being the tubular density of the gas, we shall have

$$H\,\delta \times 1{,}3\,\frac{P}{0{\cdot}760}\,\frac{a}{a+t} = 13596\,P,$$

whence

$$H = 7990\frac{a+t}{a\,\delta},$$

and

$$H - h = H\left(1-\frac{h}{H}\right) = 7990\frac{a+t}{a\,\delta}\left(1-\frac{p}{P}\right),$$

and the equation of the movement of gas shall become

$$P - p = \frac{a\,\delta\,P}{7990\,(a+t)}\left\{\left(\frac{1}{\varphi^2}-1\right)+k\frac{L}{D}+\frac{D^4 P(a+t^1)}{\psi^2 d^4 P^1 (a+t)}\right\}\frac{v^2}{2g}$$

If we wish to have the volume of the outflowing gas at every second, respectively at the temperatures and pressures P and t, and p and t^1, they will be given by

$$Q = \pi\frac{D^2}{4}v \text{ and } Q^1 = \pi\frac{D^2}{4}\frac{P(a+t^1)}{p(a+t)}v.$$

The exactness of these formulæ at low and middling pressures has been sufficiently proved by the results of the experiments made.

To illustrate them let us apply them to air moving in tubes of 0·01028 metre diameter, of the length between 0·07 and 18 metres, allowing the air to flow freely into the atmosphere under a constant pressure of one atmosphere, we shall have $\delta = 1$ and $\psi = 1$ and P^1 very approximately equal to P; further assuming $\frac{1}{\varphi 2}-1 = 1{\cdot}475$, *i.e.*, $\varphi = 0{\cdot}636$ and $t = t^1 = 20°$ $\frac{1}{a} = \frac{1}{120}$, instead of $\frac{1}{273}$ in order not to neglect the aqueous vapours existing in air, we shall have

$$Q^1 = 410{,}405\,\pi\,\frac{D^2 P}{4p}\sqrt{\frac{1-\frac{p}{P}}{2{\cdot}475+0{\cdot}0236\frac{L}{D}}}$$

in which we shall make $\frac{p}{P} = 2$ and D = 0·01028. The following Table givee the results calculated with this formula by M. Cavallero:

Length of the Tube (L).	Values of Q^1 (volume of the outflowing Gas) by experiment.	Values of Q^1 by calculus.	Differences.
Metres.	Metre Cube.	Metre Cube.	Metre Cube.
18	0·00724	0·00719	0·00005
9	0·00989	0·00989	0·00000
4·50	0·01380	0·01331	0·00049
2·25	0·01721	0·01727	0·00006
1·125	0·02032	0·02127	0·00095
0·562	0·02480	0·02471	0·00009
0·281	0·02760	0·02720	0·00040
0·14	0·02869	0·02876	0·00007
0·07	0·02869	0·02965	0·00096

From the experiments made on this subject the following empirical has been deduced:

$$v=\frac{2225}{\pi\frac{D^2}{4}}\frac{p}{P}\frac{\sqrt{D^5\,(P-0{\cdot}76)}}{L+42\frac{D^5}{d^4}}$$

which serves to the determination of the velocity, v, at the origin of the tube.

The experiments made on the hydro-pneumatic compressor of Messrs. Sommeiller and Grattoni, have proved that the formula given above does not hold for high pressures.

The same fact can be demonstrated theoretically. The loss of pressure owing to friction is expressed by

$$\frac{P-p}{P}=\frac{\alpha\,\delta}{7990\,(\alpha+t)}\,K\,\frac{L}{D}\frac{v^2}{2g},$$

whence

$$P-p=\frac{\alpha\,\delta\,K}{7990\,(\alpha+t)}\,P\,\frac{L}{D}\frac{v^2}{2g}.$$

If we now consider separately two portions of tube of the respective lengths of L_1 and L_2; and if P and P^1 and P^1 and p the initial and final pressures of the two portions, v and v^1, the velocities at the end of the lengths, L_1 and L^2, we shall have, when applying the last formula,

$$P-P^1=\frac{\alpha\,\delta\,K}{7990\,(\alpha+t)}\,P\frac{L^1}{D}\frac{v^2}{2g},$$

and

$$P^1-p=\frac{\alpha\,\delta\,K}{7990\,(\alpha+t)}\,P^1\frac{L_2}{D}\frac{v^2}{2g}.$$

$$P-p=\frac{\alpha\,\delta\,K}{\frac{7990\,(\alpha+t)}{2\,g\,D}\,(P\,L_1\,v^2+P^1\,L_2\,V^{1\,2})}$$

The temperature in the tube being constant,

$$P\,v=P^1\,v^1,$$

hence

$$P-p=\frac{\alpha\,\delta\,K}{\frac{7990\,(\alpha+t)}{2\,g\,D}\,(L^1\,v+L\;\;v^1)}.$$

Now, as

$$v^1=v+(v^1-v),$$

we have

$$P-p=\frac{\alpha\,\delta\,K}{7990\,(\alpha+t)}\,P\,\frac{L}{D}\left\{1+\frac{L_2\,(v^1-v)}{L\,v}\right\}\frac{v^2}{2g},$$

which is different to the one found above for low pressures, and the difference is directly proportional to the difference between P and P^1.

Before leaving this subject, we may refer to some very simple formulæ presented to the Royal Lombard Institute by M. Cagnoni, which are generally unknown. M. Cagnoni started from D'Aubuisson's simple formula.

$$A-a=0{\cdot}0238\;a\frac{L\,d^4}{D^5},$$

where a and A are the manometrical heights of mercury at the end and at the beginning of the tube; d the diameter of the opening of outflow, D the diameter, and L the length of the tube, putting D=·006m., and L= 400m.

(which were the conditions of the experiments made on Messrs, Sommeiller and Grattoni's hydro-pneumatic compressor), D'Aubuisson's formula becomes

$$a = A \frac{1}{1 + 123430000\ d^4},$$

when the results given by this equation were calculated, they were found two or three times higher than those the practical experiments gave.

M. Cagnoni then made the hypothesis that an elastic fluid, flowing out from a long tube of constant diameter, and under a permanent pressure, with velocity and density different in the various sections would behave approximately as a liquid, which would have a uniform velocity equal to the medium of the velocity of the fluid corresponding to the extremities of the tube, and a uniform density also equal to the medium of the densities corresponding to the same extremities; starting from this hypothesis M. Cagnoni deduced:

$$A - a = 0{\cdot}000000103\ \delta \frac{L}{D} u^2$$

in which A and a are the pressures in metres of a column of mercury at the beginning and at the end of the tube; δ and u the media density and the velocity as explained above.

Applying this formula to the determination of the coefficient

$$0{\cdot}000000103\ \delta.$$

M. Cagnoni found the following numbers substituting for A, a and u the values taken from D'Aubuisson's experiments,

$0{\cdot}000000103\delta = 0{\cdot}0000001318$
$0{\cdot}0000001311$
$0{\cdot}0000001317$
$0{\cdot}0000001325$
$0{\cdot}0000001352$

medium value $0{\cdot}0000001326$

This would show that the formula under the above hypothesis is applicable to low pressures.

M. Cagnoni, however, comparing the results given by his formula with those obtained in the experiments made on Messrs. Sommeiller and Grattoni's machine, proved that it is also very approximatively applicable to high pressures.

The following Table clearly shows it:

Velocity at the Origin of the Tube.	Difference of Pressure (A—a) obtained in Practice.	Deduced from the Formula.
1·012	0·0039	0·0046
3·197	0·0457	0·0459
3·604	0·0577	0·0571
4·106	0·0738	0·0758
4·415	0·0853	0·0877
10·157	0·3660	0·4641
15·100	0·9030	1·0260
18·460	1·5560	1·5330

The formula itself is transformed in

$$A - a = 0{\cdot}0188 \frac{b + a}{(b + a_1)^2} \frac{L d^4}{D^5},$$

introducing in it, instead of the medium velocity, a function of the diameters D and d of the tube, and of the opening of outflow, and in which $b = 0{\cdot}76$

$a_1 = \frac{1}{2}(A + a)$, L=length of the tube, and A and a keeping their former meaning.

Introducing further the quantity Q of fluent air reduced to the volume of ordinary atmospheric density, M. Cagnoni deduced

$$(b+a)^2 = (b+a)^2 + M\frac{L}{D^5}Q^2,$$

in which M is a numerical coefficient which may be taken = 0·0000002567.

It has been mentioned already that air was employed as the motive power for the perforating machinery, the compression taking place at some distance from the mouth of the tunnel, and that the compressing agent used was water. The compressors established at Bardonnèche and first used may be called water column compressors.

Fig. 29, Plate 254, shows a complete vertical section of one of these compressors. Figs. 30, 31 are theoretical diagrams of the machine, which we may use in describing the action of the machinery.

For want of space the reservoir of water from which the compression column A descends, has been omitted in the section. It has been represented only on the diagram, Fig. 30, where the vertical height of the fall through the inclined tube mentioned is represented by *f*, and the reservoir, the level of which is permanent, is marked F.

Referring now to the diagram, Fig. 29, A is the compressing column, B the compression chamber, C C the tubes for conducting the compressed air to D, the recipient, E E are the feeding valves, F discharge valves, G the compressed air valve, H H the inlet air valves, *h h h* are acceleration valves, L the actuating lever of the feeding valve, L^1 the actuating lever of the discharging valve, M M the recipient of discharge, N the escape channel, P P the regulating plane.

The supply valve E moves vertically. On the spot where it is placed the compressing column takes an annular form, and the compressing agent, instead of moving along the axis of the column and remaining cylindrical, is transferred into an annular vein, which runs along the outer side of the valve E, and becomes cylindrical again below the valve. The section of the annular vein was calculated to be equal to the section of the cylindrical column of compression, so as to leave the section of the compressing column constant throughout its height.

In the diagram the valve E is supposed to be open, and the compressing column acts uninterruptedly on the air contained in the chamber B. Now let it be supposed that the valve B is raised closing the annular space, all that part of the compressing column above the valve E will be suspended, and will cease to act on the part below, during the whole of the time that the valve E closes the annular space, and cuts off the column above, hence the function of the valve E E is to admit and to suspend the action of the compressing column. Leaving the valve E closed, let us examine the valve F. This is also cylindrical and moves vertically, opening when it rises the lateral orifices of the recipient of discharge, and closing them in its descent. Raising the valve F all that part of the compressing column below E is put, as well as the chamber B, into communication with the atmosphere, and hence the water in M and B will naturally take the level P P, determined by the level of water in the canal N, and the recipient M M. The compression chamber B will then be full of water down to the level P P, and the portion of the compression column contained in the syphon under the valve E, and in the annular portion, will not be submitted to any pressure except the ordinary pressure of the atmosphere.

The valve E remains closed during the time that the valve F makes its double stroke, and *vice versa*. If while E were open F be also opened, the water would escape with violence through the lateral orifices M M. The valve D placed at the top of the compression chamber A, by rising, allows the air after it has been compressed to escape from B into the receiver D, and closing again it prevents the return of the air. The valves H H by opening inwards admit the air into the chamber B, when the water having performed its work escapes through F.

The function of the valves *h h* will be explained presently, meanwhile it is assumed that they are closed. It is easy to understand the action of the compressor. Let us suppose the valves E and F to be both closed, and the water level to be at P P, in the chamber B, let this chamber be full of air, and the valves H H be shut.

Now allow the valve E to fall, the compressing column A A will immediately be put in motion, and rising in B will compress the air contained in that chamber; the air will be compressed until it has sufficient force to lift G, and will force into the recipient D the water following until it reaches G, when it will have lost all its velocity, the under side of the valve G will then be exposed only to the static pressure of the compressing column, whereas from above it sustains the static pressure of the air which has been driven into D, equivalent in this case to double the static pressure of the columns A A. At this moment all the compressing column up to the valve G is at rest. Let us then shut off, by lifting E, all that portion of the compressing column which is above E, and intercepts its action on the portion which is below; let us open the valve F, and the water contained in B is driven out into M M, and will flow into the canal N, the valve H H will open under the pressure of the atmosphere, and the air will enter through B, driving down the water to P P. When this level is reached the whole system will be again at rest and ready to commence a second pulsation, and to do this, let F be closed, and E opened, and the same process will be repeated.

The action of the valves is governed by the engine, Fig. 29, which regulates S, on which specially formed eccentrics are fixed, producing the vertical movement of the valves at the right moment.

Hitherto in this explanation it has been supposed that the compressing column, starting from the level P P to rise in the chamber B, commences immediately to compress the air contained therein, and the hypothesis gives the normal state of the machine, and from it those conditions are derived to which the compressor must answer to develop the greatest possible useful effect.

If a compressor were established with a chamber B of a height corresponding to a compression column likewise established, the air would not be compressed to a higher degree of tension than the use which would correspond to these data, and this circumstance would be inconvenient; however, the limits of the action of the compressor can greatly be extended, and to such a degree that the amount of compression should not depend on the height of the compressing column.

Referring again to the theoretical diagram, Fig. 31, it will be observed that from the level P P to the valve G the compression chamber has a constant capacity. The compressing column A A will always start from the level PP, and will again return to a state of rest after having reached G. The effect produced by the column, between the beginning and end of the motion, is a fixed quantity of mechanical work, the maximum limit of which is represented by the product of the volume of water, corresponding to the capacity of the chamber B, multiplied by the density of the water and for the height of the column of compression, one-half the height of the chamber B being deducted.

Now this determined quantity of work is concentrated in a volume of atmospheric air equal to the capacity of this chamber, and compressed to the tension which is to be obtained. It can, however, be compressed into a smaller volume if the pressure be increased. Whence it results that the height both of the compressing columns and the compression chamber remaining constant, it will be possible with the same compressor to obtain air at as high a tension as may be desired, so long as only such a volume of air is admitted to the compression chamber, which in order to absorb all the work of the column shall assume the corresponding tension.

This is effected as follows: The chamber B is filled with air from the level PP to the valve G, but instead of compressing the air from this level by the compression column, so much air is allowed to escape as would represent the volume by which it is wished to diminish the capacity of the chamber B, the whole effect of compression being exerted on the remaining air. The small valves *h h h* are used for this purpose, but they can be closed entirely and the compression brought to its normal state by closing all, and by regulating the

number of those shut the capacity of the chamber can be varied at will. We may assume that the compressing column has sunk to the level P'P, and is ready for a pulsation; if all the valves *h h* be closed the pulsation would be normal, but if they are open the air raised by the column will not be compressed, but will escape partially through the valves; but when the ascending column shall reach the valves it will close them successively, and when the last is shut the air will be compressed, and the volume will be reduced to an extent depending upon the relative positions of the top valve *h* and the valve G.

The mechanical effect of the water-column compressor may be expressed by the equation *

$$M = 1 - \frac{l}{2H}$$

where M is the coefficient of mechanical effect, H the height of the fall of the water at the beginning of each pulsation, *l* the total height of the chamber of compression.

The maximum effect in the production of compressed air is

$$\psi = \frac{1}{npo \log}$$

where ψ is the maximum effect in compressed air produced, *p o* the pressure external to the chamber of compression, and

$$n = \frac{P}{np}$$

where P = the pressure of the air at a given state of compression.

The relation between the useful effect derived from the expansion of compressed air and the labour expended in compression is

$$i = \frac{1}{1 - \frac{1}{k}}$$
$$k\,n$$

where *i* is the relation alluded to, and *k* the relation between the specific heat of the air at constant pressure and at constant volume. When the air is compressed to six atmospheres, as has been the case at Bardonnèche, then *i* becomes 0·41.

The water-column compressor was abandoned after a fair trial, and a simpler and more powerful compressor was adopted, which may be termed the air-compressing pump.

In this machine the water does not act directly on the air which is to be compressed, but on an hydraulic motor, which moves a piston and compresses the air.

Fig. 3, Plate 255, is a theoretical diagram of this compressor, which will serve to explain the action of the machinery.

In this diagram, E is a horizontal cylinder, in which moves the piston connected with the motor through the connecting rod *c* and the crank B. From the horizontal cylinder E two vertical and cylindrical columns F_1 F_2 rise. The cylinders E F_1 F_2 contain the mass of water submitted to the action of the piston D, which mass is put into motion by the latter, rising in one vertical cylinder and sinking in the other, and *vice versâ*, in such a manner that the volume of the space not occupied by the water is exactly equivalent to the volume developed in one half stroke of the piston.

In the diagram the piston is at the end of its stroke, and therefore E is filled with water. When the piston moves back, the level of the water in the cylinder F sinks while rising in the other up to the point when the piston D, reaching the other end of the cylinder E, the column F_2 will be entirely filled with water, and the level in F_1 will become that shown in the diagram as existing in the column F_2.

Let us now suppose F_2 full of atmospheric air, the efflux of which should be prevented; the piston D, moving in E from the left to the right, will raise the water level in F_2, and hence compress the air contained therein, reducing it thus to a smaller volume. The pressure having increased to the required degree, say, six atmospheres, the compressed air will lift the valve H, which

* See Report of Technical Directors, 1863.

communicates with the recipient I, into which the compressed air is discharged into the pump. When D reaches the extremity of E, the cylinder F_2, being entirely filled with water, all the air which was in it will have passed to I, and the valve H will close. Now let us suppose the piston moving backwards, the column of water in F_2 will begin to sink, and at its upper end a vacuum will be formed; in that same instant the valve G, under the action of the atmospheric pressure, will open, and the air will rush in and fill the space left in F_2 by the retiring column of water. As the piston D moves towards the opposite extremity of its stroke, the same action takes place in F as has been described for F_2. This machinery may, therefore, be described in a few words, as consisting of a piston producing a vertical and alternate oscillatory movement in two columns of water, which, while oscillating, alternately aspire and compress the atmospheric air.

The accessory parts of the compressor are the following: G G are valves (the use of which has already been described); they are immersed in water, which is contained in the internal recipient R. Through this arrangement the chance of leakage at the inlet valves is much reduced, as the water in R acts as a check for the passage of air, and the valves have merely to be water-tight instead of air-tight.

The valve H used for the imprisonment of the compressed air in the chamber I, is also, for the reason just mentioned, immersed in water.

Indeed, one of the principal conditions for the satisfactory working of the compressor is that there should be a sufficient water supply. 1. In order to fill all the space in which the compression of the air takes place, because if the columns F_1, F_2 are not entirely filled all the air contained in them cannot be discharged into H. with the alternate oscillations of the water columns, and hence loss of effect would occur. 2. In order to keep the valves G G and H H constantly under water. This latter condition is satisfied in a very simple manner. A quantity of water, small or large, is admitted constantly from an external vessel O, and falls upon the valve G G, as shown in the diagram. While compression takes place one of the valves G is closed, and the water which falls upon it accumulates on its surface. Now when the aspiration begins this water passes, together with the aspired air, into the internal recipient R, and thence into the compressing chamber. When the valve G closes compression begins, and the compressing column F_1, having been increased by all the water which has passed into it, together with the atmospheric air, has thus acquired an excess of volume, so that when it has driven the compressed air through the valves H, this excess of compressing water also passes, together with the compressed air, into the reservoir I I, keeping the cavity in which the valves H move constantly filled.

In order to prevent the water flowing through G from filling I entirely, and thus leaving no room for the compressed air, the following expedient was resorted to:—

A recipient L L communicates with I I; M is a spherical float which rises and sinks, actuating a valve N. The water which flows in from O through G, after having completed the passage through R, F, and H, is gathered in the recipient L L, and when it has reached a given height the floor M rises and lifts the valve N. At this moment the water contained in L L flows out through the tube P, by reason of the pressure of the compressed air. In the diagram the water flowing out through N is shown as being taken back to O.

Fig. 32, Plate 254, shows the pumps as they were erected first at Modane, and later, when their superiority over the water column compressors was also proved at Bardonnèche.

From the theoretical effect L of the fall of the water a part is lost owing to the motor employed. Another part is lost owing to the friction of the pistons and of the water in the body of the pump, and also to the loss of *vis viva* owing to rapid changes of velocity, and hence the coefficient of mechanical effect of this machine, which I shall call M, is given by the expression

$$M = V\left(1 - \frac{L\,r}{L\,\frac{r}{m}}\right)$$

where $L\,r$ is the sum of the loss arising from the friction of the piston in the

horizontal cylinders L m the elementary moving effort referred to the axis of rotation V = the coefficient of mechanical effect of the wheel in a unit of time.

The result in compressed air for each kilogram metre of effort (ψ) is

$$\psi = \frac{4\,\Omega\,l}{n} \cdot \frac{m}{L} = \frac{4\,\Omega\,l}{n} \cdot \frac{V}{L\,m}$$

where Ω is the section of the chamber of compression, l the height of the same, m the number of revolutions of the driving wheel in a unit of time, n the relation of the variable pressure p of the air and aqueous vapours during the period of compression with the atmospheric pressure ($p\,o$) or $= \frac{p}{p\,o}$, L the theoretical work of the water used for every revolution of the wheel at the pressure $n\,p\,o$. The volume of air obtained is $\frac{4\,\Omega\,l}{n}$.

The above expression may be reduced into the form

$$\psi m = \frac{V_{\bullet}}{n \log. p\,o}$$

to explain the derivation of which would lead us further than we intend to go in this article.

It will not be uninteresting to compare the mechanical effects of the water column compressors and the air-compressing pump. In order to do so clearly, let a numerical example be taken, and let it be according to the dimensions of the compressors used at the Mont Cenis Tunnel works.

The motors used are bucket wheels made of iron plates, the diameter being 18 ft. 2 in. and the width 4 ft. 11 in. The air is compressed to about six atmospheres. The uniformity of the pressure of the air in the large reservoirs is kept up through a valve properly weighted, which allows the surplus compressed air to escape into other reservoirs when the pressure exceeds that in the principal air chambers. The coefficient of mechanical effect taken theoretically for an air compressing pump of the dimensions of those used at the Mont Cenis Tunnel, and under the same conditions as derived from the expressions already transcribed, would be $= 0{\cdot}000008575 \times V$, and taking $V = 0{\cdot}75$ $\psi\, m = 0{\cdot}0000064323$.

The coefficient of mechanical effect of the water-column compressor, as derived from the expression recorded at the beginning of this article, would be, under similar conditions,

$$\psi = 0{\cdot}060006420.$$

This notice of the great Italian work would be incomplete without a description and illustration of the machinery with which the excavation was executed, and which, bearing the name of its inventor, is known as the "Sommeiller perforator."

The drawing on Plate 252 is a theoretical diagram, by which the working of the perforator can be explained; and it may be interesting to state that it was prepared from the sketch made by the inventor himself, one of the greatest engineers of modern times, who lived, not to see the work finished, but only its success assured, and who was present when the last piece of rock separating France from Italy, was removed in the tunnel with his machine. The detailed drawings given in Plates 253, 254, show the complete construction of the machine; they are taken from Signor Fautrier's report, and will be clearly understood with the assistance of the diagram above mentioned. The principal parts of the perforator are as follows: A is the main cylinder; B is the main piston rod; C C are bevil-geared wheels; D D is a driving shaft, square in section, the axis of which is normal to that of B; E is a disc with an inclined face for actuating the admission valve H; F F is the striking piston; G G the percussion cylinder; H is the valve of this cylinder; I I is the cutting chisel and its rod; K, K are the guides forming the frame of the machine; L is a pawl for regulating the forward feed of the chisel, and for rotating the chisel rod; M M is a ratchet wheel fixed on the shaft Q Q to which the movement is com-

municated; M′ M is a clutch which revolves with the shaft Q Q; N N is a worm wheel, which engages itself in the racks on the guides and which moves only when it is in gear with the wheel M M; O O is a cylinder around which is placed the spiral spring B P, which tends always to keep M′ M′ and N N engaged; Q Q is a square shaft, which, entering as shown, into the striking piston, communicates to it a rotary motion; R is a spring catch, to which is connected S; T is a tappet which, striking S, throws the catch R out of gear when necessary; U is a spring by which the contact between the catch R and the teeth of the guides is preserved; V is the fly wheel of the machine; *a* is an inlet port to the main cylinder; *b b* are exhaust ports; *a′* is a space filled with compressed air; the dottted line B, B indicates the useful stroke of the piston.

The perforator has a threefold motion: 1. One of rotation; 2. One of percussion; 3. One of advancement; this last being periodical and automatic, taking place when the rock is reduced completely in the hole made by the chisel. From the description of the various parts of the machine, as given above, the reader will have some idea of the construction of the perforator. The fixed part of the machine includes the cylinder A, with all its accessories and the guides K K. The moveable parts include the percussion piston F F, with the cylinder G G, and their corresponding details. The percussion cylinder is moveable between the guides, and as it is connected with the worm wheel N N it advances, recedes, or remains stationary, acacording as occasion may require. The percussion cylinder worked in this manner traverses a distance of 31½ in., corresponding to the ordinary depth required for the mining hole.

The fixed cylinder A gives motion to all the rest of the machine, with the exception of the striking parts. It actuates the shaft B, which through the geared wheels C C drives the square shaft D D. The eccentric E and the pawl L are connected with the percussion cylinder G G, and accompany it in all its movements, keeping always the same respective positions. The shaft D, D, being square, gives to the eccentric E, while the latter slides along it, a rotary motion; and the same effect is produced upon the eccentric which governs L.

We shall now proceed to explain the action of the perforator.

Percussion.—The piston F F, to which is fixed the chisel I I, travels in the cylinder G G. The forward face of this piston, which is annular, as shown, is constantly exposed to the effort of the compressed air, which permanently fills the space, *a′*, i.e., the valve chest of the machine. The compressed air produces the percussion by its action on the rear face of the piston.

In the diagram the machine is shown at the beginning of its stroke. The compressed air entering through the passage *a*, forces the piston forward until the point of the chisel I I encounters the rock face. In this motion the piston is pushed forward with a force equal, of course, to the area of the cylinder multiplied by the pressure of the air, and it is pushed back by another force equal to the annular surface of the forward face multiplied by the same pressure. The difference between these two forces is the true measure of the power which produces percussion.

Let us suppose that the travel of F F lies between the end of the cylinder and the line B B, so that when the chisel I I strikes the rock, the rear face of the piston coincides with B B, and all the space to the right of that line is filled with the compressed air; if no precaution were taken the piston would stop at this point, pressed on the right hand by the air, and on the left by the rock. But, supposing the opening *a* to be closed at the instant when the chisel has struck, and that the opening *b* is opened to the atmosphere, then the compressed air will escape immediately, and the rear face of the piston will only be exposed to the normal pressure of the atmosphere, which the compressed air from *a′*, acting constantly on the annular forward surface of the piston, overcomes, and the piston F, together with the chisel, returns to its first position, and is ready for another blow. The eccentric E serves for the distribution of the compressed air in the cylinder G G communi-

cating to the rod H the motion by which the ports *a* and *b* are alternatively opened and closed.

Rotation of the Chisel.—The chisel, after each stroke, revolves round its own axis for a distance equal to $\frac{1}{18}$ of its circumference. This movement is produced as follows: The pawl L, at each revolution of the shaft D D, which corresponds to an entire stroke, moves forward by one tooth the wheel M M. This wheel is fixed upon a square shaft Q, which penetrates into the piston F F, as shown, and, therefore, when L has moved round the toothed wheel M M $\frac{1}{18}$ of its circumference, the bar Q Q turns the piston to the same extent.

Advancement.—While the screw N N remains at rest when the chisel is working, the hole in the rock is constantly deepened, and the stroke of the piston F F becomes longer as the hole becomes deeper. If nothing were done to advance the whole system after a certain time it would happen that the stroke of the piston being limited the chisel would cut its way for a certain distance, and would then continue to work idly. A forward feed is therefore necessary, and this is obtained as follows: M′ M is a worm wheel which is in contact with N N. This wheel slides freely on the bar Q Q to the right and left, for a length at least equal to the length of the travel of the feed rack, and into which the teeth of the wheel M′M′ gear. This wheel is moved by L, which also drives M M. In a recess in M′ M′ is placed a rod in connexion with the catch R R R, which at the forward end is divided into two branches, bent upwards, and engaging the teeth on the lower face of the guides K K. A third branch S is only a prolongation of R, and a spring U presses R R against the teeth of K.

The spiral spring P P presses constantly the toothed wheel M M against the wheel N N, but it is counteracted by the action of the fork R.

Let it be supposed that the hole has been driven so deep into the rock that the tappet T strikes the ratchet in contact with the rack; the shock has the effect of raising from the teeth of K K the point of the ratchet; then the spring P P not being checked by R pushes M′ M′ forward, and this gearing into the wheel N N carries it on with the rotatory motion imparted to it by L by means of the other wheel M M. The wheel N N turning $\frac{1}{18}$th of a revolution at each stroke, the whole system advances in proportion. After a certain number of revolutions, the point of the fork encountering another arresting tooth of K, the fork and the catch R R stop, and the percussion cylinder advances until the clutch M′ M′ leaves the recess in the wheel N N which will then again be at rest. The stroke of the percussion piston is shortened by the distance between two teeth of K (less the depth of the excavation made while the machine runs through this distance) and will continue to increase this depth till the tappet T again strikes the point S, when a repetition of the action takes place. The variation of the stroke of the percussion piston is equal to the pitch of the teeth of K. The normal stroke is determined, first, by the working condition of each perforator; second, by the velocity the workman wishes to give to the successive strokes. When the velocity is greater the impetus with which the chisel strikes the rock must be smaller, and *vice versâ*.

Retrograde Movement.—The excavation of the hole being finished, the machine is caused to recede by turning from right to left the wheel N N, and without inverting the motion of the cylinder A. This manœuvre can be executed with the utmost facility.

As will be seen from an inspection of the detailed drawings, the machines actually employed, differed considerably in their arrangement from the sketch we have described, although the principle of the perforator remained the same. The differences consisted in the manner by which the cutting-tool was turned, and the percussion cylinder advanced. Figs. 1 to 4 are general elevations, plan, and longitudinal sections of the perforator, from which the modifications will be understood. To effect the rotation of the cutter, the square shaft penetrating the percussion piston was abandoned, and the arrangement shown in detail, Figs. 23 and 24, Plate , adopted. The square shaft *q*, Figs. 1, 2, and 3, Plate , which is driven by the bevel gearing *r r″* from the main cylinder, is extended to the forward end of the machine to the point where

the main frame terminates (Figs. 5 and 6, Plate 253), with a plate shown in end elevation, Fig. 23. Upon the square shaft *q* an eccentric *e''* is placed, terminating in a finger *s* which is kept in close contact with a ratchet wheel by a spiral spring *m'* fastened to the end plate of the frame. As the shaft *q* revolves, the eccentric and pawl constantly turn the ratchet wheel, and so impart motion to the cutting-tool. An essential difference of detail is also found in the mode of advancing the percussion cylinder, as shown in details, Figs. 11 to 20, and 27 and 28. The two latter figures show the form given to the pawls that engage in the rack on each side of the frame. It will be seen that in the centre, between the pawls T, there is a finger, the relative position of which, and that of the socket *n* (Figs. 1, 2, and 3, Plate 253), will be seen. The short arm, Figs. 27 and 28, carrying this finger and the pawls, is hinged with a T piece to two horizontal levers *t t* which unite at therear end to form a clutch *a'*. But between these two levers, and immediately above the short forward arm carrying the pawls, is a rod *r*, the end of which A forms a piston and passes through a packing into the opening *g'* of the valve chest of the machine, as shown in Fig. 3, and in details, Fig. 12. Now, when the cutting tool has so far penetrated the rock that the surface *n* of the socket of the holder comes in contact with the finger T it, and the spring *m'* Figs. 27 and 28, which keep the pawls in contact with the rack is pushed up. So soon as the pawls are released thus, the compressed air in the valve chest of the machine, acting on the small piston or rod attached to T as described, and entering the valve chest at *g'* forces the whole system forward clear of contact with *n*, and the pawls dropping engage with another tooth of the racks. But while this is done the two arms *t t* are also carried forward, and the forked end in which they terminate, and which lies in the groove of the sliding clutch I, Figs. 12, 13, and 14, pull the clutch forward, and engage it in the worm wheel W, which then commences to turn, and continues to advance itself and the whole moving parts of the machine by means of the rack formed in the sides of the frame, until it winds itself out of contact with the clutch I. It is necessary to add that this latter is kept in motion, and slides upon the block E (Figs. 12 and 14), and which is driven off the shaft *q* with an eccentric and pawl, Fig. 20, somewhat similar to that used for rotating the cutting tool. With these variations in detail the machines as actually used were similar to the sketch we have previously described. The detailed drawings on Plates 253, 254, may be summarised as follows: Figs. 5, 6 are plan and longitudinal section of the frame, showing the racks on the edge, and the teeth on the top of the frame; Figs. 11, 12, and 14 are an end view, section, and plan of the percussion cylinder, valve chest, and gearing for advancing the cylinder; Figs. 15 to 20 show the gearing employed for this purpose; Figs. 21, 22, are the sliding clutch I and the front view of the worm wheel W into which it engages; Fig. 7 is the pipe which is screwed into the valve chest at *f'''* for admitting the compressed air from the reservoir; Figs. 8, 9, and 10 are views of the cam disc for moving the slide valve; Figs. 25, 26, show the slide valve itself; Figs. 23, 24 is the arrangement for turning the tool cutter. In the former of these figures the keys *b b* will be seen, which enter key ways cut in the shaft of the tool holder, and form guides. Fig. 27, 28 are details of the advancing apparatus already described.

The perforators used weighed in all 440 to 660 lb.

The form which was found to answer the best for the chisels was the section of a **Z** at the striking end, because the hole had to be made circular, and yet an exit had to be left for the triturated rock; a **Z** shaped cutter revolving, as described above, easily produced this result. The length of the chisels was variable, and their sizes at the end varied from $1\frac{9}{16}$ to $3\frac{1}{2}$ in. in diameter.

The perforators were grouped on iron frames in the tunnel, which moved on wheels running on rails, the latter being laid down in the headings as the work went on. Vertical screws, on which the two ends of the perforators rested, allowed the same to be inclined in any direction; they could also be submitted to lateral movement by screws and gearing. The weight of each of these stands was about 12 tons. The compressed air was led to the perforators by flexible tubes of 30 or 40 feet in length; these tubes all terminated in a distributor, which was put into connexion with the tube leading

from the entrance of the tunnel. There were also on the stand two tubes of iron by which jets of water were admitted.

The workmen were employed in companies, and the working time of each company was about eleven hours; it consisted of three distinct periods: 1st. the perforation of the holes; 2nd, the loading and blasting; 3rd, the clearing of the detritus. Of these periods, the longest naturally was the first, the quantity of work generally done was about 20 cube yards excavated by each company of workmen during the eleven hours. The advancement of the heading obtained by the same was about 6 ft. in eleven hours.

In conclusion we should mention that the chief part of the foregoing information is derived from the reports of the technical directors of the works, and from those of MM. Cravasana, Favarro, Fettarappa and Gauten, supplied by Mr. Francis Kossuth, Commissioner of Italian railways.

Norway.

From Norway were sent to Vienna a collection of drawings illustrating in considerable detail the cheap system of narrow gauge railways, adopted by the Government of that country, and carried out so successfully by Mr. Carl Pihl. It should never be forgotten that since the system he inaugurated has been studied and understood it has been repeated in all parts of the world, until despite all the prejudice brought to bear against it, narrow gauge railway construction is recognised to possess all that has been claimed for it, by the few unbiassed and clear sighted advocates who have so persistently, and at last successfully urged the advantage, or rather the necessity of narrow gauge railways.

Although the railways that have been constructed in Norway are short, and form only as yet an imperfect system, which even when completed, will be confined within but contracted limits, yet it is the only country in which a standard narrow gauge has been established, and it is there that the theory of cheap railway construction was applied perfectly for the first time to practice. To Norway the representatives of many governments have repaired to judge for themselves how far so contracted a system may be recommended for adoption elsewhere, and to what extent economy could be effected in construction and subsequent working. It is not a little to the honour of Norway, that she should thus have proved a school to other countries, that she, poor in inhabitants and in resources, should have ventured on an experiment from which others, better provided for, had shrunk; and it is not a little to the honour of Mr. Carl Pihl, that he, as engineer to the Norwegian Government, should have long, and with ultimate triumph combated with prejudice and opposition at home, and worked on through ridicule and discouragement from abroad.

Before however deducing any conclusions from Norwegian railway experience, we will consider what that experience has been, and collect in as comprehensive and brief a form as may be the statistics of the Norwegian system of railways. The first line of railway was constructed by Mr. Robert Stephenson, and was opened in 1854. It was of 4 ft. 8½ in. gauge and had a total length of 42¼ miles extending from Christiania to Eidswold on the Lake Mjösen to the north. Seven years later a branch to Kongsvinger towards the east was added, and this, subsequently extended, goes to complete the railway communication to Stockholm. The original line from Christiania to Eidswold cost 11,750*l.* per mile, a sum greatly disproportioned to the revenue, which it was possible to obtain from it, even under the most favourable circumstances, and it was evident that unless another mode of construction could be adopted, Norway must continue altogether without railway extension. But it was considered that the cost of this line was excessive, and that railways being an absolute necessity, cheaper ones must be built. Accordingly the branch to Kongsvinger was placed in the hands of Mr. Carl Pihl, who had been appointed government engineer, and by him it was completed for the sum of 5,856*l.* a mile, this sum including rolling stock, and showing a saving of 5894*l.* per mile on the original line. Thus a great advance in economical construction was attained, and the line so com-

pleted has been worked with a fair amount of profit. But the first of these railways, commenced in the capital and terminated on the borders of a lake, where a large timber trade is carried on, and the second connects the metropolis of Norway with that of Sweden. Occupying therefore the most favourable situation for the developement of traffic, the revenue they yield makes them fairly profitable undertakings, the first line paying 3·66 per cent. and the second 5·72 per cent. of the invested capital.

But a still further reduction in the cost of construction was absolutely necessary before railways could be made through less favourable districts, occupied by a scantier population, and in which trade was poor; and it was evident that the work must be founded on a more economical basis, commencing in a reduction of the width of gauge, the weight of rails, the class of works and rolling stock, and carried through the whole system to its minutest details In extending the Christiania and Lake Mjösen line, a break of gauge was of no importance because the railway terminates on the margin of the lake from the other side of which, in the town of Hamar, the first of the new lines was constructed, for a distance of 24 miles to Elverum, at a cost of 3,270*l.* a mile, including stations, rolling stock, and workshops. About 144 miles north of Elverum, a second line, 30½ miles long, and of similar construction, was opened for traffic in 1865, two years later than the Hamar Elverum. By this northern railway the towns of Trondheim and Storen are united, and it is now proposed by the Norwegian Government to build 145 miles of railway to complete the connexion between Trondheim and Christiania via Lake Mjösen. The works upon the Trondheim Stören line were excessively heavy, involving much rock excavation and long viaducts, the cost was therefore somewhat in excess of the line previously built, having been 5,300 a mile, inclusive of everything, and the same difficulties were met with in the Drammen and Randsfjord railway, a line completed subsequently, to the west of Christiania, and 56 miles in length, terminating on the Lake Tyrifiorden. The estimated cost of this line was 4,563*l.* per mile, an estimate which proved to be excessive, the actual cost having been about 4,380.

Thus about 110 miles of narrow gauge line have been constructed in Norway, at a total cost of 504,500*l.*, including all expenses of equipment, and some 112 miles of railway 4 ft. 8 in. wide, at a cost of 909,500*l.*, of which 493,500*l.* were expended in building the 42¼ miles by Mr. Robert Stephenson, and 416,000*l.*, in making the branch, 72 miles in length, under the supervision of Mr. C. Pihl. The economical system of railway construction having been thus demonstrated, the Norwegian government are now about to extend their existing railways, and propose to form an additional length of about 275 miles in all. A part of this is indeed in course of construction at the present time, and the remainder is under consideration. There would be five new lines all of a 3 ft. 6 in. gauge. The first would have a length of 30½ miles, and connect the Drammen Randsfjord Railway with Christiania, at a cost of about 7,000*l.* a mile, the country being difficult and the amount of work excessive. The second proposed railway would be the Hougsund-Kongsberg, a branch of the Drammen and Randsfjord line, 17½ miles long, and cheaply built. The Vickersund-Kösderen line, 15 miles in length, a second branch from the same line, and about 210 miles of railway to join up the Hamar-Elverum and the Trondheim-Storen line, as before mentioned. Sixteen miles of this are now in progress, and their estimated cost varies from 2,000*l.* to 4,000*l.* a mile.

It is almost impossible to institute an exact comparison of cost between two railways of differing gauges, and constructed over different country, on account of the cost of work varying with the nature of the ground. Thus one of the new lines just recommended to the Norwegian government is estimated to cost one-sixth more per mile than did the 4 ft. 8½ in. line to Kongsvinger, whereas another sinks as low as one-third the price of that line. Obviously the only way in which such an exact comparison could be instituted would be by the careful location and estimating of the two systems over the same country.

But while exact comparison is thus difficult, the districts through which

the broad gauge, Kongsvinger line, and the narrow gauge, Hamar Elverum line, are built, are sufficiently alike in character to enable us to arrive at some idea of the comparative cost, it being borne in mind that in the construction of the former, the strictest possible economy was observed in every detail.

——	Kongsvinger.	Hamar Elverum.
Gauge in feet - - - -	4 ft. 8½ in.	3 ft. 6 in.
Weight of rails in lb. per yard - -	62 lbs.	37 lb.
Steepest rising gradient - - -	1 in 200	1 in 86
Steepest falling gradient - - -	1 in 250	1 in 70
Degrees of curves per mile of line -	325°	274°
Maximum degrees of curves on one quarter of a mile.	234°	186°
Minimum radius of curve - - -	1,000 ft.	750 ft.
Difference between highest and lowest level.	156 ft.	45 ft.

The following table gives the cost per mile of every detail connected with the construction of the line:—

——	Kongsvinger.		Hamar Elverum.	
	£	Per cent.	£	Per cent.
Ground appropriation -	229·25	3·92	90·40	2·72
Fencing - - -	85·40	1·42	88·90	2·72
Rock and earthwork - -	1,942·50	33·19	890·00	27·22
Bridges and viaducts - -	321·75	5·50	103·00	3·15
Deviation of roads - -	64·35	1·10	28·50	0·87
Permanent way and ballast -	1,568·55	26·79	933·00	28·56
Stations and sidings - -	418·70	7·15	445·80	13·63
Rolling stock - -	749·50	12·72	427·00	13·07
Telegraphs - - -	33·00	0·56	26·40	0·81
Sundry works - -	42·50	0·74	46·00	1·42
Engineering and supervision -	400·50	6·84	189·00	5·78
Cost per mile - -	5,856·00	100·00	3,268·00	100·00

It will be seen that the rails used upon the Kongsvinger line were of the excessive weight of 62 lbs.; and that by reducing them to 37 lbs. upon the Hamar Elverum, a saving of 635*l.* per mile was effected, as well as 1,042*l.* per mile in the earth work, and 322*l.* in the rolling stock. The engineering charges were also considerably less per mile upon the narrow than on the broader gauge. The following tabulated statement gives the particulars of rolling stock upon the two lines.

——	Kongsvinger.	Hamar Elverum.
Number of engines - - -	9	3
„ „ per mile - -	·13	·43
„ passenger carriages - -	35	8
„ „ „ per mile -	·5	·34
„ goods trucks - - -	272	50
„ „ „ per mile - -	3·84	2·1

Although the principal economy effected in the earthwork is dependent upon the nature of the ground, increasing in hilly country, where there is much cutting in sidelong ground in a rapid ratio with the gauge, and being small on a level surface, the engineer of the Norwegian government in forming the narrow gauge lines decreased the quantity considerably by reducing the widths in a greater proportion than the difference of gauge. The width of formation on the 4 ft. 8½ in. is 18 feet, and on the 3 ft. 6 in. is only 12 ft. 6 in. both in cutting and embankment, in each case of course for a single line. The lighter permanent way, amply heavy, however, for the amount of traffic, the simplicity of the viaduct work, nearly all built of round timber, the cheapness of the stations, and the rolling stock, of which only sufficiency for the purpose of working the traffic is purchased; all these things combined have produced the cheap railways of Norway, and given that country a railway system, of which, under other circumstances, she would have been deprived. The special gauge adopted by Mr. Pihl has succeeded in this difficult country, where a broader one would have failed; but it has succeeded by virtue of a constant watchfulness in reducing outlay in every possible manner. We regret that we have not space to investigate the details of the traffic carried upon these railways, nor the cost of working them, as compared with the wider gauge.

All the Norwegian railways with a 3 ft. 6 in. gauge are laid with a single line of rails throughout, and their width at formation level is four metres, or 13 ft. 1 in., this width being, however, slightly reduced in some parts. The width at the top of the ballast is 8 ft. 4½ in., and the thickness of the ballast 2 ft. The rails are of the Vignoles section shown in fig. 3, Plate 256, and they weigh from 37 to 44 lb. per yard. They are fish-jointed, as shown in Figs. 3 and 4; the fish plates being 11 in. long, and being secured by four bolts ¾ in. in diameter. The rails are carried on half round transverse sleepers 8 in. to 8⅓ in. diameter, and 5 ft. 7 in. long, placed at a pitch of 2 ft. 11⅓ in. from centre to centre on the straight parts of the lines, and 2 ft. 7 in. on curves of less than 600 metres, or 1,968 ft. radius. The rails are secured to the sleepers by dog-spikes 4½ in. long. Figs. 5 and 6, Plate 256, show respectively a section and plan of a small length of the line, and Figs. 7 and 8 represent the form of a switch handle employed. The lines are drained by ditches formed on each side of them, and they are protected throughout by post and rail fences.

Figs. 9 to 16, Plate 256, are various transverse sections of the lines, showing the system of construction adopted in different localities. Fig. 9, represents the line in shallow cutting, and Fig. 10 in cutting through rock. In the latter case the face of the rock upon which the ballast rests is formed to a slope of 1 in 12, and the ballast is protected by a low stone wall on the lower side, the space between this wall and the side of the cutting forming a drain. Fig. 11 shows the system of construction adopted in carrying the lines on embankments over marshy lands. The ground is first drained by forming deep trenches on each side of the intended line of railway, and the foundation of the embankment is then formed by laying fir timbers across and across, as shown in the engraving. On these timbers are laid the branches of the trees forming the timbers, and on these the materials of the embankment. It is found that the embankments thus constructed stand remarkably well, and form an excellent road even on very bad ground. Fig. 12 shows an embankment on sidelong ground, the surface being stepped to afford a hold for the materials of the embankment, and the toe of the latter being formed by a kind of stone retaining wall. Fig. 13 shows an embankment and retaining wall constructed on a sloping surface of rock; and Fig. 14 a method of carrying the line along ground with a very steep side slope. In this latter instance a cutting is made along the slope on the higher side of the line, and a retaining wall put in, as shown in the section. The earth excavated from the cutting is used to form a kind of half embankment, which is held by a second retaining wall, as shown. There is also a low retaining wall on the high side of the embankment, the space between this and the retaining wall

of the cutting forming a drain. Figs. 15 and 16 show a method of constructing the drains under embankments.

The intermediate stations are constructed of wood on stone foundations, and their arrangement will be seen from the perspective view and plan of one of them, which are given in Figs. 1, 2, Plate 259. Each station includes two waiting rooms, an office for the ticket and telegraph clerk, and accommodation for the station master; and there is also at another part of the platform a depôt from which light goods are forwarded. In the case of stations where there is a heavy goods traffic, the goods depôt is traversed by a siding.

The bridges and viaducts are in some instances of timber throughout, and in another consist of iron superstructures carried on stone piers. Of one of the iron bridges we give a perspective view on Plate 255. It is a Warren girder bridge of five spans, the three central spans being of 100 ft. each, while the side spans have openings of 85 ft. and 50 ft. respectively. The system of timber viaduct construction, which has been designed and worked out by Mr. Pihl, is shown by Figs. 17 to 24, Plate 256, which represents the arrangement and details of a timber viaduct constructed on an incline and curve. The structure consists of a series of spans of 20 ft. each, and it is composed throughout of round timbers, the greater number of which are of an uniform length. Figs. 17 and 18 are respectively an elevation and plan, and Figs. 19 and 24 are transverse sections; and from these views the system of bracing will be readily understood. Each pier, it will be seen, is formed of three sets of vertical timbers, assisted by raking struts, which slope inwards, so as to meet at the head of the central vertical timbers of the pier. The piers are crossed at intervals of 20 ft. in their height by horizontal timbers, and from the joints where the upper range of these cross the piers, diagonals proceed upwards and inwards, and support the longitudinal timbers on which the rails are laid, directly in the centre of each span. The mode of connecting these diagonals with the longitudinal timbers is shown by Figs. 20 and 21, and Figs. 22 and 23 show the manner in which the junction of the vertical timbers of the piers and the horizontal timbers and diagonals is effected. It will be seen that on the pier represented in Fig. 24, a second raking strut is shown on the left-hand side. These additional struts are only applied to the outside of curved viaducts, straight viaducts having the struts arranged as shown in Fig. 19. This system of viaduct construction is admirably adapted for use in a country like Norway, where there is an abundant supply of timber of small scantling, but where large timber is difficult to obtain.

Permanent Way at the Vienna Exhibition.

One great development of civil engineering work during the last few years lies in the construction of railroads, which have become, financially as well as technically, of ever-increasing importance. The railways of the world were estimated in 1871, to extend over nearly 125,000 miles, or about six times the circumference of the earth at the equator. The rolling stock for these lines represents a capital of about 50,000 million pounds sterling, and about 15 million tons of rails are required, together with nearly 5 million tons of other parts for the permanent way. Not less than 25,000 tons of rails have to be renewed every day, and of the 250 millions of sleepers forming the timber portions of the railways, about 36 millions become useless every year, these containing about 100 million cubic feet of timber.

The desire to reduce the cost of maintenance, and to increase the safety of railways, is proved by the demand for an improved and less expensive permanent way. This demand has led to much experimental engineering, and we have actually had an attempted return to stone block sleepers, while a vast amount of ingenuity has been expended in improving the details of rails with broad feet consisting of several parts, in devising rails of great depth with narrow bases, and in constructing an almost endless number of systems of iron permanent way. Also, we have had the extensive introduction of steel as a material for rails and permanent way details, as well as the re-introduction of the suspended fishjoint, with improved fishplates, and the improvements of the signal arrangements for switches, &c.

In dealing with the permanent way of railways, and searching at Vienna for proofs of the progress which has been made during the past few years, we may divide the exhibits into the following heads :—1. Substitution of another material for the expensive wooden sleepers, or modes of prolonging the life of the latter by chemical means. 2. Making the rails in such a manner that the head may be renewed whilst the bottom or base remains. 3. Increase of the stability of the joints of rails, and general application of the suspended fishjoint. 4. The improved arrangement of switches, and their direct connexion with the signals.

Examining now with respect to the first division of the classification given above, the various systems of sleepers exhibited at Vienna, we cannot but express our regret that England did not show some of the many systems of iron permanent way which have from time to time been designed by English engineers, and which have been adopted to a large extent abroad. The systems of iron permanent way exhibited at Vienna were practically Continental, but were sent only from those countries where the supply of timber is decreasing—as, for instance, from Belgium, France, and Germany; whilst Austria, with an abundant supply of timber, has not made a trial at constructing an iron permanent way.

The new systems of permanent way, however, were not confined only to iron constructions, but include also other materials. In the Swiss department of the Machinery Hall was a new system of permanent way, consisting of asphalte blocks, and iron ties and rail fastenings, exhibited by Mr. E. Stierling, of Schaffhausen. Stone blocks have lately been applied again in Wurtemberg, Baden, and Bavaria, as a substitute for timber sleepers, and have given, with respect to safety and durability, satisfactory results; but their want of elasticity, and the fact of their being the cause of a great wear and tear of the rolling stock, has prevented their general application. Mr. Stierlin proposes now with his new asphalte blocks to get over this difficulty, and states that they possess the durability of stone and the elasticity of timber. These asphalte cubes or blocks consist of a mixture of asphalte and small pebbles, which melts only at a temperature of above 200 degrees, and which, it is claimed, withstands not only the most powerful heat of the sun, but also, on account of its composition, all disadvantageous influences of the atmosphere. The blocks have the shape of a cross, are 150 millimetres ($5\frac{7}{8}$ in.) high, and are said to carry 150 tons. A double T-iron is cast into the block in such a manner that the flat top is level with the surface of the block, and serves as a base for the rails, which are fastened to the blocks by means of two bolts cast into the latter and formed by one piece of iron, bent into a U shape; these bolts, however, do not pass through the base of the rails, but loose clips are used for keeping down the latter.

Into the bottom flange of the double T-iron, and also cast into the block, is hooked a piece of bar iron 5 millimetres × 50 millimetres ($\frac{3}{16}$ in. × 2 in.), which projects a few inches beyond the side of the block; tie bars 18 millimetres ($\frac{11}{16}$ in.) diameter, with bent ends, are passed through holes in these projecting parts, and they are fastened simply by a nut, thus securing the gauge of the line. The inventor does not propose to apply this arrangement of tie rods to each pair of blocks, but as often as may be found to be required. The ordinary block on Mr. Stierlin's system offers to the rail a fixed and immovable support 60 centimetres, or nearly 2 ft. in length, and this is claimed by the inventor as a great advantage; but this length of support depends entirely on the size of the blocks, and the support may be made a continuous one if the latter are placed close to each other. Whether this system of permanent way has been tried or not, we do not know, but it appears to us to possess nothing that could recommend it for adoption, if we consider the many systems of iron permanent way which really possess some advantages, and which are, as yet, used to a limited extent only. Mr. Stierlin's system may be cheap, but its construction and material will certainly not be approved of by many railway engineers.

Cross sleepers of cement by a nameless exhibitor were found in the neighbourhood of the pavilion of the Nordbahn; the rails are fastened, as would be expected, by bolts cast into the sleepers. Nothing, however, need

be said about these sleepers, and as the exhibitor does not care to show his name, we may suspend any opinion, and simply state that they were even then in a dilapidated condition.

Langhor's system of iron permanent way is well known to railway engineers, and a similar one formed of Zore's iron cross sleepers was exhibited in the Belgian department by Messrs. A. Hauwart and Jean Cabuy, of Ixelles, Brussels. The exhibit consisted of two full-sized models, one for a flat-footed rail, and the other for a rail without any bottom flange, but consisting only of top head, and web. It is stated that this system has been tried over a short distance, but with what results cannot be ascertained. A decided disadvantage in this system appears to be the entirely insufficient bearing surface of the cross sleepers, this being only a little over 3 in., so that the sleepers must necessarily be placed at very short distances from each other. A new fastening has been adopted in the case of the flat bottom rails, and for those without a bottom flange; for the former two double hooks, which grip the bottom flange at each side, are used, and the lower part of these hooks extends along the sides of the Zore's iron through which a bolt is passed in order to keep the two double hooks firmly in their position. For the rails without a bottom flange the upper part of the fastening plates is formed like a fork, by which the web of the rail is gripped, the firm position being secured, and dislocations prevented, by an iron wedge, which is driven between one side of the fork (which is provided for that purpose with a corresponding groove) and the web of the rail. Whatever merit these fastenings may have, they certainly would not stand the traffic on our English railways. We may mention here that the same exhibitors showed also a model of rails for tramways, constructed on a similar principle.

The best collection of exhibits of permanent way systems was in the German department of the Exhibition. In the Machinery Hall was a model of Köstlin and Battig's three-part permanent way, in which the rail has a loose head or top part, whilst the web and flanges are again divided into two equal parts, which carry between them the head or top part of the rail, they being themselves fixed like a saddle upon longitudinal sleepers of T-shaped section. The system has been tried on the Würtemberg as well as on the Saxon State Railways, but with different results; the administration of the former railway complain much about the high cost of maintenance, whilst the results obtained on the Saxon lines are stated to have been more favourable. The system seems, however, to be of an unnecessarily heavy construction which must naturally make the cost of maintenance very high; the system appears further to be too rigid, whence lateral dislocation must be a natural consequence in a severe climate. The next system of iron permanent way was found outside the eastern side of the pavilion for the Westphalian and Rhenish iron industry; it is the well known two-part system of Hilf, exhibited by the Royal Prussian Administration of the Nassau Railways. This system is well known on the Continent as the most successful one with iron longitudinal sleepers, and a direct fastening of the rails upon the latter; it has been widely adopted on Prussian and German railways (either on account of its own recommendation or on account of the official position of its inventor), and new and interesting experiences having been gained with it during the last few years.

The illustrations, see Plates 257, 258, show besides the construction, its application to sidings and switches, and the manner in which the permanent way is laid down. Figs. 6, 7, and 10 of Plate 257 show the arrangement of the permanent way, which consists of iron longitudinal sleepers, to which the rails are secured, the gauge being maintained by tie bolts passing through the web of the rails. The latter, a section of which is shown in Fig. 4, Plate 258, are of Bessemer steel, and made for the Nassau Railways in lengths of 6 metres (19 ft. 8¼ in.) each, and weigh 48 lbs. per yard; these rails are 4¼ in. high, with a bottom flange of 3⅜ in. wide, and a top flange $2\frac{3}{10}$ in. wide.

The other dimensions, both for the rails and the sleepers, as well as the manner of fastening the former to the latter, are clearly shown in Figs. 1, 6, 7, and 10, Plate 257. Recently cast-steel rails, notched only at the ends, and secured by a bolt *a*, Fig. 6, placed on one side of the rail to prevent a longitudinal

displacement of the latter, have been employed. A further alteration has been made in the arrangement of the tie bolts between the rails, their number having been reduced from three to two per length of rail. The weight of the whole structure per length of six metres (19 ft. 8¼ in.) is as follows:

	lb.
Two rails, each six metres long -	647·46
Two longitudinal sleepers -	757·46
Bolts, nuts, and washer plates -	40·21
Tie bolts with nuts and washers	34·45
Fishplates with bolts and nuts -	44·35
Total weight for a line six metres long	1523·93

or 232·64 lb. per yard.

Taking the prices of iron paid in 1872, the cost for material, excepting ballast, is about 28*s.* 11*d.* per yard; to this has to be added 2*s.* 6*d.* per six metres of line for fitting up the permanent way in the shops, and 3*s.* 9*d.* per six metres for laying, so that the entire cost laid down amounts to about 30*s.* per yard.

Figs. 1, 2, 3, 4, and 5, Plate 257, show the application of Hilf's permanent way to switches and sidings. Fig. 1 represents the section through A B in Fig. 2, which consists of a combination of two lines of rails so laid that a train may pass from one line of rail to the other in either direction, or which, by another setting of the points, may remain on the same line of rails; the characteristic of this switch is that the centre is not between the two lines of rails, but within the line of rails, so that two frogs are saved; only two are required, as will be seen from Fig. 2. The necessary widening of the gauge for the curves, the distance between sleepers, and the lengths of the various pieces, are marked in the engraving. This double switch is constructed for a lead of 1 to 10. Fig. 3 represents a single siding for a lead of 1 in 12, and a radius of 945 ft. 9. in. The widening of the gauge is also shown, as well as a separate diagram of the various distances between the curved and the straight parts of the rails. Fig. 5 represents the dimensions of the tongue of the crossings required for the angle corresponding with a lead of 1 in 12. The following is the mode of calculating these dimensions adopted by continental engineers:

The sin. of the angle B under which the one line of rails crosses the other is $\frac{1}{12}$, or

$$\text{sin. } B = 0{\cdot}08333,$$

whence

$$\text{cos. } B = \sqrt{1 - \text{sin.}^2 B} = \sqrt{1 - \left(\frac{1}{12}\right)^2} = \frac{\sqrt{143}}{12} = \frac{11{\cdot}9583}{12} = 0{\cdot}99652$$

therefore

$$\text{tan. } B = \frac{\text{sin. } B}{\text{cos. } B} = \frac{\frac{1}{12}}{\frac{11{\cdot}9583}{12}} = \frac{1}{11{\cdot}9583} = 0{\cdot}08362,$$

or

$$B = 4^\circ\ 46'\ 49''.$$

The object of calculating the cos. of the angle of crossing is to find the widening of the gauge at the point where the rails are jointed to the tongue of crossings, as the sum 1321 (Fig. 4) + 109·9 (Fig. 5) = 1430·9, which, multiplied by cos. B, gives 1430·9 × 0·99652 = 1426 millimetres (4 ft. 8½ in.) the gauge at the points mentioned above. The object of calculating the tan. is simply to facilitate fixing any point of the crossing lines by means of rectangular co-ordinates.

Figs. 8 and 9, Plate 257, show the formation and drainage adopted in connexion with Hilf's iron permanent way for a double and single line of rails on the Nassau State Railway. To facilitate laying down the permanent way on the line between Diez-Zollhaus, a length of about nine English miles, a

double-jibbed crane, as shown in Figs. 1, 2, 3, Plate 258, was used with great advantage. This crane, the construction of which will be easily understood from the engravings, was fixed to a strong four wheeled trolley or platform wagon, which was also provided with boxes containing the various tools and appliances necessary. The crane wagon had attached to it two open freight wagons loaded with material, and a locomotive for moving over the newly laid down rails. Whilst one of the arms of the crane takes up from the goods wagon a longitudinal sleeper, with the rail fastened to it (a weight of about eight cwt.), a second sleeper and rail is laid down on the ballast by the second arm of the crane, and is fastened to the preceding sleeper and rail, when the tie bolts are put in, and the correct gauge is secured. This method has proved highly satisfactory.

This system of permanent way has been adopted to a greater or less extent for the following lines: The Nassau State Railway, on the Rhenish (Eifel) Railway, on the Palatine Railway, as an experiment, between Ludwigshafen and Neustadt; on the Lower Silesian, Upper Silesian, Eastern Railway of Prussia, and Lower Rhenish Railway, in all, however, only about 65 miles.

The results obtained by the experience upon the different lines are, as we have said, satisfactory, and the cost of maintenance has been scarcely a third of that for ordinary permanent way.

On the south side of the same pavilion were two other systems of iron permanent way, one of which is exhibited by the Burbacher Hutte, and is the well-known system of Vautherin, which has been adopted on nearly all the railways of France, Belgium, and Switzerland, as well as on the Prussian State Railways. The trapezoidal section of the sleeper and the fastening of the rails are well enough known, and do not require any further description. The other system exhibited on this side of the pavilion is represented only by a drawing, and belongs to Mr. C. Schaltenbrand, of Wesel, in Prussia. Although the system is new in some respects, it neverthless possesses in general much similarity with other now systems of iron permanent way. Like Vautherin's system, the cross sleeper in Schaltenbrand's system has a trapezoidal section; it is, however, not open at the bottom or larger side, but closed by a plate of sheet iron, and the inventor proposes to fill up the hollow space between the walls of the sleeper with concrete, pebble, or elastic material. Whether that will be of any advantage or not, experience will perhaps show, but it has certainly until now been considered a great advantage of the trapezoidal section of the cross sleeper, that the bedding and position of the latter is to a great extent secured by having the large side of the trapezoid open, so that the sleeper may rest like a saddle upon the ballast. The construction of the joints of the rails in Mr. Schaltenbrand's system is a new one; the joints are suspended, and the fish-plates are formed by angle irons which rest with one side against the web of the rail, and with the other on the bottom flange. This latter side, however, is larger than the bottom flange of the rail, and its edge is bent over and fits into a groove of a plate which passes under the bottom flange of the rail and supports the latter from sleeper to sleeper, a distance of about 2 ft. Although this manner of jointing two rails together may be a little expensive, it certainly offers great stability and security. This construction is shown in Figs. 3 to 8, Plate 259.

In the pavilion of German art and industry was a model of an iron permanent way, adopted and exhibited by the Rhenish Railway Company. This system, which is a two-part one, is similar to that of Hilf, but the side flanges of the longitudinal sleepers are very short, which appears to us an improvement, because the proper bedding of the sleeper is thus facilitated. The joints of the rails are placed near the ends of the longitudinal sleepers, and the fish-plates consist of two parts, one of which is shorter than the other; the larger part grips with one end the bottom flange of the rail, and the other end is bolted down to the longitudinal sleeper, whilst the shorter part of the fish-plate has an angular section, extending with one side over the flat part of the fish-plate and gripping with the other side the web of the rail; these parts of the fishplate on each side of the rail are connected with bolts passing through the web of the rail. Between the German pavilions and the Machinery Hall was an arrangement for the securing of the

rails on switches, exhibited by the Cologne Minden Railway, as well as by the manufacturers, Messrs. Windhoff, Deters, & Co. The system, which is in principle that of timber cross sleepers, consists of a wrought-iron plate being placed for the length of the switches between rails and timber sleepers, the movable rail sliding either on wrought-iron keys—in which case the fixed rail with flat bottom flange is bolted through the wrought-iron plate directly to the timber sleepers—or on cast-iron blocks which form part of the fastenings for the fixed rail. In the French department of the ministry for public works we find chairs and rail fastenings, as used for many years on French, and partly on Italian railways.

With respect to the preparing or creosoting of timber sleepers, there were samples of the latter, after a use varying between 10 and 15 years, exhibited by the Upper Silesian Railway, the Rhenish Railway, and the Northern Railway of Austria.

Before proceeding to a detailed consideration of the exhibits which come specially within the scope of the present notice, we may take the opportunity of referring to a contribution of extreme value and interest, furnished by the Austrian North-western Railway Company. It consisted of a large pavilion containing, as far as possible, all the representative material, so to speak, required for a main line of railway, from its inception to its completion and subsequent working.

The pavilion itself was fitted up as a type railway station, with waiting-rooms, booking office, luggage depots, &c., all of these being thoroughly furnished, and in full working order. The waiting rooms, moreover, contained copies of all official documents relative to obtaining the concessions, preliminary studies, finished plans and sections, duplicates of contracts and schedules, drawings of station bridges, and other works, and tabular statements of quantities, weights, and costs; the printed rules and regulations for working the traffic were also exhibited, as well as extensive tables and diagrams showing the extent, direction, and variations in the goods and passenger traffic through a period of three years. Diagrams also showed the percentage and distribution of working expenses, the variation in income, the number of accidents, and cases of sickness or casualities among the members of the staff of the company. In addition, a complete set of tools and appliances supplied to all the minor stations was included, together with complete descriptions and data upon the number, extent, and arrangement of the repairing shops belonging to the company. The exhibits comprised in addition a locomotive and carriage shed, and a yard in which were samples of rails, turntables, switches, crossing, weighing machines, signals, signal boxes, &c.

A somewhat similar pavilion was shown by the company of the Kaiser Ferdinand Railway of Austria, but this latter exhibit was not so comprehensive, comprising chiefly locomotives and carriages.

Both of these pavilions were admirably arranged, and the idea of bringing together and classifying such a mass of valuable material was very effectively carried out.

Rails of the so-called Vignoles section, now in general use on the Continent, were almost exclusively represented at the Exhibition, where nearly all European iron works and rolling mills of reputation contributed steel or iron rails, and the French, German, Belgian, and Styrian sections especially sent steel rails of excellent quality, shown, however, by so many exhibitors that it would be impossible for us to refer to all of them here. Naturally the exhibits of steel rails occupied the first place, both in number and importance, and showed clearly that with the ever-increasing demand new centres of manufacture spring into existence.

A few examples of steel-topped rails were also exhibited, a form adopted upon some of the main Austrian lines, as for example, upon the Kromprinz Rudolph Railway.

Few novelties in compound rails were to be found at Vienna. In the Belgian department of the Machinery Hall, however, was a model of such a rail, exhibited by Messrs. Durieux and Co., of Louvain. This rail is formed of two parts, the one consisting of the foot, the web, and an upper flange, in

the upper face of which is a groove; the other part is a saddle, the upper face of which forms the top table of the rail. The sides of this saddle embrace the web, and extend down to the bottom flange of the rail. The saddle fits in the groove formed in the top of the upper flange, and is bolted to the web of the rail, by bolts placed 2 ft. 3 in. apart. The saddle pieces are rolled in about 10-ft. lengths, and are so placed as to break joint with the other part of the rail. In the Belgian section, also, a compound tramway rail was exhibited by Messrs. J. Cabuy and Hanwaert, consisting of a ⊥-shaped web, bolted to T-irons 2 ft. long, and placed at intervals of 2 ft. These act as sleepers and have bolts to each of the three brackets which embrace the ⊥-web and lower head of the rail, the whole being held together by bolts passing through the brackets, the web, and the head of the rail.

Another system of chair rails for tramways was exhibited by M. Giovanni Righetti, of Trieste, in the Austrian Educational Department. The chairs, each of which weigh 70 lb., are connected with each other by gauge rods above which stones are placed. The rail is fastened in the chair by means of iron wedges.

Chairs of different designs, and with wooden wedges for the fastening of the rails, were exhibited by the French Ministry of Public Works.

While but few novelties in the construction and arrangement of fishjoints were shown at Vienna, there were several devices exhibited for locked nuts of fishbolts. The first of this kind that we may mention was that by Mr. Hohenegger, shown in the pavilion of the Austrian North-western Railway, of which we have given a description above. Hohenegger's system, shown in Fig 5, Plate 258, consists of an iron plate $\frac{3}{10}$ of an inch thick, with a hole for the fishbolt, and a slot at one side which allows a part of the plate to be bent back. The plate or washer is placed under the nut, but the side is bent up only after the permanent way has been in operation for a sufficient length of time to allow the bolts to take a set, the nuts being tightened before the washer is adjusted. If afterwards the nuts should require to be again tightened, the side of the washer may be easily bent by means of the key made for the purpose. The weight of the plates is about one-tenth that of the bolts. This is a simple and comparatively efficient arrangement of locking the bolts, and is largely used upon the North-western Railway of Austria. The idea, however, possesses no novelty. Ronetz's detail, having a similar object, and which was exhibited in the Austrian Educational Department, is in principle the same as Hohenegger's, with the difference, however, that all four sides of the plate may be bent back.

A third exhibit of the same nature was that of Mr. G. Weickum, shown amongst his other exhibits in the Austrian department of the Machinery Hall; the arrangement is being generally adopted by the Austrian State Railways.

The same exhibitor showed also a neatly arranged adjustable joint, connecting the rails of turntables and traversing platforms with the fixed line of rails. The special feature of this joint, an illustration of which is seen in Fig. 6, Plate 258, is that it attaches the rails on the turntables rigidly to the main rails, so that the former cannot shift when a load passes over them. The shifting fishplates forming the joint are attached to the ends of the rails upon the table or traverser, and the required movement is effected by means of a lever.

Similar joints have been used for a considerable period on turntables in the terminal station at Vienna, of the Austrian State Railway.

With the exception of a few ordinary fishjoints, which were exhibited in the French section by the Ministry of Public Works, only two other exhibits of this class were to be found, one showing the suspended fishjoint adopted by the Bergisch-Markischen Railway, and the other the spring fishplates of Mr. Dering, in the English section of the Machinery Hall. An illustration of these fastenings is shown in Figs. 7 to 12, Plate 258.

Of tools and apparatus used for laying or maintaining the permanent way of railway only two novelties were exhibited, but several collections of ordinary plate-laying tools were to be found. Of these, the most complete was that

exhibited by the Austrian North-western Railway Company in the pavilion referred to at the commencement of this article.

One of the two new tools, just mentioned for the laying and maintenance of permanent way, was exhibited in the Austrian department of the Machinery Hall by Mr. M. Pollitzer. It is called an "equalizator," and is intended for levelling permanent way, for testing gauge, and finally for checking the super-elevation of the outer rails upon curves. The apparatus consists of an iron frame, mounted upon wheels, and carrying suitable hooks connected with lifting screws attached to the side of the carriage. When in operation the apparatus travels over the line of rails, and when depressions occur, the hooks are placed beneath the rails, which are then lifted as far as necessary by means of the screws. It is in addition provided with an automatic registering apparatus, by which all lateral and vertical irregularities in the road are graphically recorded.

In connexion with this exhibit we may mention the "rail leveller" of Messrs. De Bergue and Co., which was also exhibited in the Machinery Hall, and which is in extensive use upon continental railways.

The rail-bending apparatus exhibited by Mr. Emil Schrabetz, of Vienna, is a well-designed and efficient tool, and one which possesses much to recommend it for adoption. By its use rails can be quickly bent, and the whole of the apparatus does not weigh more than 80 lb., so that it also has the great advantage of portability. The apparatus consists of two coupling links, and a pair of small frames, made of flat bars, containing within them a system of jointed levers, which can be moved by means of a three-threaded screw passing across the frame, and one half of which has left-handed, the other right-handed threads cut upon it. Attached to these levers is on one side a suitable saddle to bear against the under side of the rail to be bent, and on the other a similar saddle pressing against the abutment. In operating it, several rails are laid together with wedge distance pieces between them, and the links before spoken of are slipped over the ends of this group of rails and also over those of the rail to be bent. Between the group of rails and the latter, the pair of frames before spoken of are interposed, one near each end in such a manner that the saddles take their bearing against the former and the side of the latter respectively. On turning the right and left-handed screws by means of a lever, the system of jointed levers is expanded, and thus force the rail into a curve, the degree of which is regulated by means of a graduated scale attached to each of the frames.

Railway Signals.

The means adopted for facilitating and simplifying the traffic on stations, and to prevent, by properly worked switches and points, and by direct connexion of the latter with the signals, the running of trains over wrong lines and sidings, were best represented at the Vienna Exhibition by the model of the well-known signals of Messrs. Saxby and Farmer, of London. Although these apparatus are familiar to every English railway engineer, they have not yet been introduced on Austrian railways, and Messrs. Saxby and Farmer's exhibits were consequently a point of great attraction to visitors. The small station of the Austrian State Railway, at the northern entrance to the Vienna Exhibition, was experimentally provided with a set with six levers on Messrs. Saxby and Farmer's system.

A modification of Messrs. Saxby and Farmer's system was shown in a model by Messrs. Schnabel and Henning, of Bruchsal, at the Vienna Exhibition. The exhibitors, who have erected several of these signals on the Continent, claim to have improved several details of construction.

One of the chief objections in Messrs. Saxby and Farmer's apparatus is the strain thrown upon the long rods for transmitting the motion, by which the stroke of the lever may be effected, and the lever for the signal set free, but the tongue may not be firmly pressed against the stock rail, so that a danger of the train leaving the rails may exist. Messrs. Schnabel and Henning, accordingly, have adopted hydraulic power instead of rods for transmitting the motion, and this idea was carried out by the inventors in the hydraulic switch arrangement exhibitied by a model at Vienna.

As this apparatus, however, has never been applied in practice, we will confine ourselves to a brief description of it without expressing any opinion on its working; time and actual use will soon prove whether it is practically successful.

The model of Messrs. Schnabel and Henning's apparatus, designed for a station with one main and one branch line, is provided with two levers only, which refer to the chief positions of the lines, as the signals are altered automatically after the points have been arranged by the pressure of the water. The horizontal valves and ratchet levers are similar to those of Saxby and Farmer's apparatus, and are used for the same purpose. The manipulation of pointing the switches is as follows: An accumulator is first filled with water by a pump from a tank under the apparatus, producing the acting power. By moving the switch-lever a valve is opened, and the water is allowed to pass into the communicating pipes, and thence to the switch. After the tongue has been pressed firmly against the stock rail, and having opened by this motion the valve of a second communicating pipe, the water is liberated, and passes finally to the distance and traffic signals, which are worked by the lifting of a second and smaller accumulator. Finally, the water returns to the apparatus, where a third accumulator is lifted, and a small black board is raised before the pointsman with the words, "Open for traffic," so that he is assured that all the movements have been properly carried out. On reversing the switches, the water circulates in the opposite direction. The inventors propose transferring in this manner the motion with perfect safety over a distance of 8,000 feet.

Of distance signals three systems were represented at Vienna, which have all found extensive use on Continental lines. These systems are that by Hohenegger, exhibited by the North-western Railway of Austria, the system introduced and exhibited by the Allgemeine Telegraphen-bau Gesellschaft, of Vienna, and the system of signals introduced on the Saxon State Railways some time ago by M. Baron von Weber, now consulting engineer to the Austrian Board of Trade; this latter has been adopted, and was exhibited at Vienna by Mr. Carl Thomaso, of Dresden. The first of these signals is electro-magnetic, whilst the two others are optical signals. We have to mention here a well-designed draw-barrier or gate for level crossings, exhibited by Messrs. A. Wilke and Co., of Brunswick, which is worked by a single chain, and is connected with a bell arrangement. A chief peculiarity of this arrangement is that the bells begin to ring before the pole is lowered, and that the gate-keeper is obliged to ring the bells before he can bring down the pole.

Examining the systems of switches represented at Vienna, we may mention two, one by Hohenegger, belonging to the exhibits of the North-western Railway of Austria, and the other one exhibited in the Hungarian department of the Machinery Hall, by Messrs. Paravicini and Clement. The engraving of a switch on Messrs. Paravicini and Clement's system is given in Fig. 9, Plate 259. This arrangement consists chiefly of an iron bar *a b* between 6 ft. and 10 ft. long, of strong section, and fastened to the outside of the rail, which is next to the stock-rail of the switch. The one end of this bar is carried by a bolt passing through a bearing *c*, and the web of the rail, whilst the other end is provided with a nose placed under the head of the rail in order to prevent the untimely lifting of the bar. At a corresponding distance from the latter end of the bar a wedge *d* is fastened, which rests upon a wedge *f* of the same shape, and slides over it on pointing of the switch. This wedge *f* is connected by the bell crank *g* and the rod *h* with the tongue of the switch; the bell crank is fastened with its fulcrum *k* upon the bearing plate *i*, which serves also as sliding surface for the bell-crank at the point where the wedge *f* is fastened; the two wedges *d* and *f* have inclined sides of 45 deg. In the normal condition of the switch the bar *a b* is level with the rail, whilst during the changing of the points, the motion of the tongue is transferred by the screw bar and the bell crank to the lower wedge, which presses with its inclined surface upon the top wedge, so that the bar *a b* is lifted over the level of the rail, but sliding back on the other side of the wedge occupies again its normal position. If the tongue, however, is not firmly pressed against the stock-rail, the bar *a b* will project above the level of the rail, but it will be pressed down by the wheels of the passing train

when the tongue is forced into its proper position before the wheels have reached it.• This safety arrangement is intended for preventing the danger of running off the rails if the tongue is not placed in the proper position. It is stated that practical use of this arrangement has given satisfactory results.

The tongues are simply moved by hand, and the turning of the signal disc is effected by the same lever; this latter is connected with the lever V, which is provided at the upper end with an oval hole through which the pin x is passed with one end, whilst the other end is connected with the upright bar which carries the signal disc. Moving the lever V will therefore produce a turning of the upright bar and the disc.

Of turntables and weighing machines, there were many exhibits, but few novelties. Of the former we may mention that exhibited by the North-western Railway of Austria, but built for this company by the Grazer Wagon Works. See Fig. 13, 14, Plate 258. This turntable, which has been built according to the specifications of the railway company, consists of the casing, the circular frame for the rollers, and the table, the latter being 15 ft. 1½ in. in diameter. The casing, which is 2 ft. high, is made of cast iron, and consists of six parts, which are bolted together, and to the inner circumference of which is fastened a circular double frame carrying the rails, this frame being connected with the central bearing by six radial arms of ⊥-section, 10 in. wide by 1¼ in. thick, and having a central web 4¼ in. high. On the rail carried by this frame run the rollers, of which there are 12, made of chilled cast iron, and having a diameter of 12 in.; these rollers are connected with each other, by angle irons, and with the central bearing by wrought-iron rods 1 in. in diameter, as shown in the cross section.

Another circular frame, to which is fastened a rail similar to that of the bottom frame, is bolted to I-girders, 10½ in. high and 4⅝ in. wide, with a central web ⅜ in. thick, the rail carried by this frame resting on the 12 rollers already mentioned. This latter frame with the four I-girders, forms the table or platform, in the central part of which is fastened a diagonal frame for the support of the casing of the centre pin. The rails are flat steel bars, and are fixed upon the four I-girders, while the whole of the platform is covered with thin chequered iron plates. In order to reduce any shock that may be thrown upon the centre pin, there are arranged around the casing of the latter four vertical spiral springs, upon which the upper part of the casing is placed, and through which is transferred the pressure received through the diagonal frame from the four girders carrying the rails. The outer casing has the usual eight stops for the purpose of fixing the position of the platform, so that the rails upon it may correspond with the rails of the adjoining lines.

Turntables of the ordinary construction were also exhibited by the Maschinen and Wagon Fabrik of the Hungarian States Railway, of Buda-Pesth, and by Messrs. Windhoff, Deters, & Co., of Lingen-on-the-Ems. A new construction of turntable was shown in the Austrian Department by Mr. G. Weickum, whose invention will most probably have a good future, and before long his system may be substituted for the ordinary construction on account of its simplicity and cheapness. Mr. Weickum's modification of the ordinary construction consists chiefly in substituting balls for wheels, a mode proposed many years ago, and which has been carried with practical success in the United States. The advantages of this turntable, compared with the ordinary ones, are a lighter and simpler construction; the substituting of steel balls for rollers; these balls run between two rails with grooved top surfaces, and are kept in their position by means of iron double-flanged guide bars. The friction during turning is thus considerably reduced, diminishing, therefore, the cost of maintenance, and the small height of the construction, so that the fitting up and fixing is much facilitated. Locomotive turntables have been constructed on this system, 40 ft. in diameter, and the turntable exhibited at Vienna, with a diameter of 10 ft., was in use during the erection of the Rotunda, and gave high satisfaction. The balls in this turntable are not of steel, but of cast iron, and the wear and tear is insignificant, notwithstanding the heavy loads that have passed over them. Mr. Weickum has

applied his system of balls also to traversers and travelling platforms, and to iron cranes, a small model of the latter having been shown at the Exhibition.

Weighing machines were exhibited in the German, Belgian, and Austrian departments of the Machinery Hall. We may mention the weighing machine for 20 tons, with iron foundation and suspended lever edges, exhibited by the North-Western Railway of Austria; the weighing machine for the same weight for road and railway carriages, exhibited by the Maschinen and Waggonbau Gesellschaft in Simmering, near Vienna, and that for weighing locomotives exhibited by Messrs. Schember and Sons, of Vienna. This latter was the most important of all in the Exhibition. Want of space prevents us from saying more than that the machine has been designed for the purpose of measuring the load of each wheel of the locomotive, so that according to this weight the springs may be adjusted.

We have already mentioned that the pavilion of the North-western Railway of Austria represented a station entirely fitted up, and we cannot conclude this notice without mentioning a curiously arranged system of a so-called flying station, designed by Mr. Lazar Poparics, station-master on the Austrian State Railways, and which is intended, especially during time of war, to accumulate a large number of men at any point of the line, and to send them off in any direction within a few hours' time. The chief point in this arrangement is a circular line, which is built at the side of the main line, and which is connected with the latter by curves and sidings. The inventor proposes to get the trains on this circular line, and without interfering with the traffic on the main line, to fill them up with passengers, and to run them on to the main line, and off to the place of destination. The arrangement is chiefly intended for strategical purposes, but the advantages it possesses are not apparent, while its disadvantages are many and obvious.

The Kahlenberg Railway.

We may conclude this section by a short notice of the mountain railway recently completed up the western side of the Kahlenberg, which was illustrated by models and drawings at the Vienna Exhibition.

The notion put into practice a few years ago by Mr. Sylvester Marsh, of Chicago, of building a holiday traffic railway up the side of a mountain, was successfully imitated by the engineers of the now famous Rigi Railway, and more lately by the construction of a line up the side of the Leopoldsberg, near Vienna.

The Mount Washington Railway of Mr. Marsh surmounted a rise of 6,000 ft., with gradients of one in three, and the rolling stock employed gave the general plan for that afterwards used upon the Rigi Railway.

The Leopoldsberg line differs from the latter, which ascended the mountain on one side only, whereas the one under consideration scales both sides, one being in course of construction on the east, and the other, a rope railway, having been completed on the west side of the mountain.

The situation of the railway line is to be seen in Fig. 1 (see Plate 260), where both stations are drawn in their relative positions with horizontal curves, showing the configuration of the ground. The vertical distance of the horizontal curves is 10 klafters, or 60 ft. The lower station A is put into direct communication with the town of Vienna by means of the Emperor Franz Joseph Railway.

The upper station of the mountain railway at C is placed on the top of the mountain, and its horizontal distance from the lower station is 2,492 ft, whereas the height above the latter is 793·76 ft., which corresponds to a gradient of 34 per cent., or to an inclination of the permanent way of 19 deg. to the horizontal.*

As will be seen from Plate 260, the railway is laid with a double line, the guage being 6 ft. 2⅝ in., and the distance between the centres of the two lines of rails six metres, or 19 ft. 8¼ in. The traffic is conducted as follows:

* The profile of the line is shown in Fig. 2, Plate 260. The configuration of the mountain's surface necessitated the adoption of curves in the vertical direction, as will be seen at *a*, *b*, and *c*.

On each line of rails is placed a passenger carriage, constructed as shown in Figs. 6, 8, and 9 (see Plate 261), there being also placed on each line below the passenger carriage a tank wagon or tender, shown by figs. 10, 11, and 12, and weighing 6¾ tons. The passenger carriages are, as will be seen, two storied, the lower story consisting of two first-class and three second-class compartments, each compartment holding 12 passengers, while the upper story, to which access is obtained by end steps, affords seats for 40 third-class passengers. Each carriage thus carries 100 passengers in all.

Each of the passenger carriages is 30 ft. 10 in. long by 10 ft. 9⅓ in. wide outside, and 18 ft. high vertically above the rails, while the weight empty is 15 tons. The general construction will be at once seen from the illustrations, but we may say a few words here respecting the mode of haulage. As will be seen on reference to the longitudinal section, Fig. 6, Plate 261, provision is made for the *two* ropes. Of these the upper one is the hauling rope proper, while the lower one is the safety rope, the use of which we shall explain presently. The hauling rope is, as will be seen, attached to the drawbar of the carriage, this drawbar being furnished at its lower end with a coupling for the attachment of the tender. The lower rope, on the other hand, is connected through the intervention of a draw-spring and pair of links with a nut fitted to a long screw fixed beneath the carriage; these screws being capable of being turned by means of a transverse shaft, which is connected to it by bevel gear. The use of this screw is to adjust the length of the safety rope. The ropes are each 2 in. in diameter, and each is composed of 114 steel wires three millimetres, or 0·18 in. in diameter.

We have now to describe the arrangements for haulage. The hauling rope from each carriage is carried up the incline, and attached to a winding drum driven by the engines at the upper station, as shown in figs. 3, 4, and 5 of Plate 260. One of the ropes passes direct to the upper side of its drum, while the other is led down under the engine-room so as to meet its drum on the underside, and thus as the two drums *a a* always rotate together the one rope is wound up as the other is uncoiled, and *vice versâ*. The safety rope, to which reference has already been made, carried the two carriages, it being led round an inclined wheel W, situated at the head of the incline, as shown in figs. 3 and 4, and thus by means of this rope the ascending and descending trains would be connected, and thus tend to support each other even in the event of the hauling ropes failing. The wheel W has a deep V-groove in its periphery, and is fitted with a powerful steam brake, so as to obtain a control upon the trains, independent of that afforded by the brakes on the main winding drums *a a*.

Figs. 3, 4, and 5 already referred to will explain the general arrangement of winding machinery. The winding drums *a a* are 22 ft. 7⅝ in. in diameter, and are driven by a pair of non-condensing engines with cylinders 24⅞ in. in diameter and 6 ft. 2½ in. stroke, fitted with link motion. The gearing is arranged so that the engines make two revolutions to one of the winding drums, and the maximum speed of the ascending and descending trains is three metres, or a little under 10 ft. per second. The time generally occupied in the ascent or descent is about five minutes.

The engines are worked with steam at a pressure of 75 lb. per square inch, supplied by boilers of the locomotive type, situated in an adjoining building, four of the five boilers being usually worked. The feed-water is drawn from a covered reservoir constructed near the boiler house, as shown in fig. 4, this reservoir receiving the water brought up by the tenders or tank wagons already referred to, as there is no water supply available at the top of the incline. During the ordinary traffic the tenders are not much used, but in the evening, when most of the traffic is "down-hill," they are attached, and the ascending one being charged with fuel and water, serves to balance the descending loaded carriage. In this way the water and stores are raised to the level of the upper station practically without the exertion of engine power.

The permanent way consists of sleepers and longitudinal beams carrying the rails. Between the rails two central length beams are provided to carry the rolls for the support of the rope.

The engine and all the mechanical arrangements have been constructed by the well-known firm of G. Sigl, in Vienna, and the results of the trials, as well as the working of the engine, reflect every credit upon the builder.

The whole work has been carried out under the superintendence of the very able manager of the Union-bau Gesellschaft, Mr. Edmund Stix, under very difficult circumstances.

We may yet mention that every accommodation has been made by the Union-bau Gesellschaft named above, for the revival of the desponding travellers after having gone through the exciting ascension. The erection of a large and commanding hotel on the top of the Leopoldsberg, commanding a splendid view over the Danube and the adjoining shores, is one of the principal points of attraction for the inhabitants of Vienna.

EDUCATIONAL APPLIANCES.

There is but small occasion to dwell at length on these exhibits; it will be sufficient to give a general idea of what was done at the Vienna Exhibition to represent the various stages of popular and technical education.

It is a popular but very pardonable error to attach an exaggerated importance to the educational departments in universal exhibitions. Dazzled by a multiplicity of objects, many of which still shine in their primal lustre, the visitor easily takes an incomplete and desultory collection as a standard by which to estimate the status of education. Such a conclusion is unjust, and such examiners of course hasty and superficial. For example, Great Britain had no educational exhibits at all; are we thence to infer that a veil of Cimmerian darkness envelops the three kingdoms? America had only a collection of school furniture; are we to conclude from this that our Transatlantic cousins are rude and benighted? To be able to institute a comparison with an appearance of fairness, every country and every department of instruction should have been represented. Now this was very far from being the case in Vienna, and it can scarcely be otherwise but that a similar incompleteness must, more or less, be the characteristic of every universal exhibition. In this, as in other specialities, governments and institutions give unequal encouragement to exhibitors of different classes, and the same authority that, for example, extensively patronises textile fabrics or agricultural machinery, may entirely neglect educational institutions. Besides, there was so little inducement to exhibit, that with two or three exceptions higher establishments refrained from being represented at Vienna. It is thus patent that the *ensemble* of those exhibits was not typical of the actual state of education in Europe, though there were several sections which certainly indicated an advanced stage of instruction.

England, Spain, Portugal, and Italy had no educational galleries. In the American and Swedish pavilions most of the exhibits were articles of school furniture. There was no luxury whatever in the accommodation, though elegance and comfort were not entirely eliminated. Our schools and colleges would greatly gain in appearance if a little more attention were only paid to those two points. Austerity and gloom are too often the leading features of our school system, and it would doubtless be a progressive step to borrow a little of the American amenity.

The French gallery showed that much attention and a large share of talent are concentrated upon devising the best means of primary instruction, of smoothing the asperities, and rendering the first stages of learning easy and agreeable to youth. There is, indeed, no country in which more vigorous and successful efforts are made to encourage and stimulate the young student, and in this respect French schools are worthy of imitation. The exhibits comprised arithmometers to facilitate the simple rules, geographical reliefs in plaster, to give accurate notions of the fundamental definitions; variously-coloured maps, showing, by their difference of shades, the altitudes of countries above the sea level; and models of solids, with sections, to render tangible the principles of practical geometry. A careful examination of the various systems of drawing showed that the French department is pre-eminently the best, both as regards the course of linear drawing, with zinc and plaster models of penetrations and architectural designs, and the cardboard apparatus for descriptive geometry of the Christian Brothers, and the ornamental drawings of M. Bargue. A very good collection of the former may be seen in the Educational department of the South Kensington Museum. In the French gallery was also exhibited a very complete apparatus for perspective, representing the ordinary devices for showing the object and its image, but differing from them in giving the vertical and horizontal projections. This ingenious apparatus was made by one of the Christian Brothers, of Paris. It is only

just to this energetic society to add that in the French and Belgian educational sections they occupied an eminent position. M. Strösser's collection of geometrical figures may be mentioned here, a system pretty well known in this country. It has many advantages, which render it very valuable for a demonstration, but it has the drawback of being too fragile. Solidity, not delicacy, is the chief requisite, and for this reason the French system of wooden and zinc solids is preferable.

In physical apparatus, the only collections were to be found in the Austrian and German departments; and these presented considerable deficiencies. There was evidently a lack of system a little perplexing to visitors who wished to examine the specimens of apparatus belonging to each branch of physical science. The tables were, indeed, covered with instruments, but without any appearance of classification. The branches most imperfectly represented were optics and acoustics. In the former there was little beyond a few concave and convex mirrors, one or two microscopes and telescopes, a very nice spectroscope, and a series of small prisms—too small to be of any practical utility to the teacher, who would find it difficult to give a lesson on the formation of images, or on the decomposition of light, with this diminutive apparatus. Precisely because optical experiments involve certain difficulties in manipulation, the instruments should be calculated to reduce these to a minimum. Acoustics and optics were, as already said, twins in point of incompleteness, and the number of exhibits of the former class was very scanty, and included a sonometer, a Savart's resonant, a few tuning-forks and organ reeds. Of course it is not to be inferred from this that light and sound are not seriously studied in German schools, the facts are just the opposite; but the fact of this incompleteness clearly shows that universal exhibitions cannot be taken as indices of the status of education.

In mechanics several good models for the demonstration of first principles were exhibited. The mechanical powers, with the sole exception of the screw, appeared well adapted for elementary instruction, but at the same time it must be stated that none of the collections equalled in completeness and convenience that generally used in our schools, viz., that of Professor Willis. There were several of the simplified forms of Atwood's machine, which would doubtless have looked better if the stops, strings, and weights had been only put in their proper places.

In hydrostatics and hydraulics there were some excellent models, especially of pumps, tourniquets, and fountains. The collection of pyronomics, though very incomplete, presented a few very good specimens of apparatus. It is not a little singular that there was exhibited a Wedgewood, and a differential pyrometer, but no thermometers beyond one of Leslie's, which, by the way, had no liquid in the stem. Papin's digester, and Marcet's boiler, should be found in every cabinet of physics; but then prudence and convenience require that they should be of goodly dimensions, and well rivetted. Those in the Exhibition did not possess these qualities.

In pneumatics there were only a small number of exhibits, and even these were scattered over a considerable area. The old-fashioned air pump seemed to prevail. The best specimen was Mariotte's apparatus for investigating the elasticity of gases. Of the various departments, the electric and magnetic were decidedly the best represented. There were a few apparatus for statical experiments—such as jars, electroscopes, spangled tubes, metallic cylinders—that strongly resembled their prototypes, such as are illustrated in books published in the last century. The electric machines most in favour, and deservedly too, are those of Holtz and Winter. The former is certainly beautiful and imposing. It involves and offers a striking illustration of induction; but by reason of the complication of its parts, and its high price, it is not a piece of apparatus that will find its way into many schools. Winter's will always be found a ready, convenient, and very satisfactory machine. From an 18-in. plate, a 12-in. and 20-in. spark is obtained; and under favourable circumstances, quantitative sparks 28 in. in length are given. All those in the Exhibition had the rubbers insulated; and this is to be preferred, as the lecturer may then experiment either with the positive or the negative electricity. Moreover, it is always easier to make earth connexion than to

secure good insulation. In the galvanic collections a peculiarity was prevalent which cannot but throw difficulties in the way of the experimenter, namely, the fixity of the clamps. There was scarcely a cell in which these appendages were movable, and yet every one who has made an experiment in galvanism knows how much the strength of the current depends upon the connexions. Of the coils exhibited, not one provided was with the later improvements. Though good coils are made in some of the Continental capitals, not one of those at Vienna was equal in finish, or superior in results to those of Mr. Apps, Strand. There were several good sine and tangent galvanometers, but none of the ordinary multipliers; several Morse, but no needle or dial telegraphs. Ampère's currents, especially the soleroid, were of rather indifferent construction, and Geissler's tubes were insignificant.

For technical instruction there were two classes of exhibits, which speak very favourably of the standard of instruction given in the establishments which have sent them. The first was the kinematical collection of M. Reuleaux, professor in the Polytechnic School of Berlin. There were upwards of 100 models, or one-fifth of the whole collection. The simplest and most difficult problems in kinematics—from the production of rectilinear motion to the development of some of the most complex curves—were all illustrated by finely-executed models devised by the professor, and made in the workshops of the Berlin Polytechnic.

Great credit is due to Professor Reuleaux for the very ingenious manner in which he has divested this abstruse subject of some of its greatest difficulties.

The second class referred to in the preceding paragraph was the collection sent by the Polytechnic School of Moscow. This institution has lately had a new life infused into its veins by its distinguished director, V. Della-Voss. The method introduced by this savant may be briefly described as eminently systematic and practical. Unlike the Technical School of St. Petersburg—which in several points has been re-modelled on that of Moscow—it receives the engineering aspirant at the age of 11 or 12 years. The morning is spent in the class-room, and the afternoon in the workshop. Gradually the young pupil is led through the circle of technical science, and at the same time through the most useful stages of practical engineering. Of course it is not every pupil that will attain eminence in both departments of this extensive curriculum; but special aptitudes are noted and cultivated accordingly. There were good collections of models of bridges from the School of Dresden, and of link-motions and sections of engines from Schröder, of Darmstadt.

The chemical branch of the Educational Department did not occupy much space, and there is not much cause for surprise at this. The laboratory need not contain a large assortment of instruments. Tubes, tubing, jars, and especially chemical products, are the items with which an ingenious professor—devising his apparatus as needed—will know how to unravel the marvels of science to an admiring audience. Such appeared also to have been the opinion of those who have contributed the chemical exhibits—for apart from the chemicals themselves, which were more calculated to please the eye than to satisfy the mind, there was not a bad collection of the other staples.

In conclusion, it may be said that the greatest deficiencies were noticeable in the departments allotted to middle-school exhibits. Those of the two extremes, primary and technical, were the ones which afforded the most satisfaction, and which best repaid the time spent in examining them.

SCIENCE EXHIBITS.

The advanced branches of science were well represented in the Vienna Exhibition. There was not a great variety, but most of the specimens embodied the very latest improvements, and in many instances were veritable triumphs of science and monuments of mechanical skill. These exhibits were not grouped together in the same compartment, but were scattered throughout courts and pavilions, which were not often in close proximity to one another. It was therefore not without a large expenditure of time, and a considerable amount of locomotion, that one could get a general idea of this speciality, but the knowledge gleaned from a careful inspection well compensated for the labour involved in obtaining it.

The bulk of these exhibits was to be found in the French and German galleries. England, America, Switzerland, and Russia had also their collections. We must confess that the English section did not realise the ideal we had formed. This disappointment, however, was not caused by the inferiority of our exhibits, but by their fewness and by the absence of contributions from several of our houses which enjoy a well-deserved and long-established reputation for the excellence of their instruments. Switzerland had three, France four, and Germany nine times as many exhibitors.

Siemens Brothers had an extensive collection of telegraph apparatus; Cook and Sons (York) had the largest and most elaborate portable equatorial telescope in the Exhibition. The hour and declination circles are graduated in silver, and the whole construction is remarkable for the fineness of its finish. Mr. Pulvermacher had an attractive display of galvano-electric bands and Faradaic pocket induction-coils; Heinke and Davis maintained the reputation they have achieved for the completeness and perfection of their diving equipment. Mr. Pillischer had, among other articles of interest, a standard thermometer and a barometrograph, which daily recorded the variations of atmospheric pressure. We shall return to several of these exhibits subsequently. In the French department there was a collection of prisms of various sizes from the establishment of C. Feil; silver and platinised mirrors, dioptric and cosmoramic lenses from that of Cetliffe. An eminent position was given to a plano-convex lens of crown glass, 17 in. in diameter. M. Nachet had some very good microscopes; one in particular attracted our attention; it is a binocular, intended for delicate scientific investigations. M. Duboseq exhibited several spectroscopes, and a very beautiful electric-light lamp and regulator. In the German section there was a large assortment of lenses, theodolites, goniometers, spectroscopes, and polariscopes. These last were exhibited by Schmidt and Haensch, of Berlin.

From the great number of exhibits we shall select for description only a few of those which embody some novel features that may contribute to make them objects of special interest.

Mr. Friedrich Siemens of Dresden exhibited a new caloric motor which possesses several interesting features. It consists, like all motors of a similar class, of a "cold" and a "hot" part, which are suitably connected by regenerators, whilst it differs from other heat engines by being driven by the action of gravity on a fluid, no cylinder or piston being employed.

The artificially-cooled part *a*, as well as the part *a'* (fig. 1, Pl. 241), heated by fire, consists of a hemispherical vessel with 12 partitions; these partitions are fixed, however, in the upper part only of each vessel, whence the 12 compartments *b* (fig. 2) communicate with each other in the lower part of each vessel. Each upper part of a "cold space" is connected by means of the tubes C and a regenerator R (fig. 3) with a corresponding "hot space."

As shown in these vessels *a* and *a'* thus connected with each other 12 times, are fixed upon an inclined shaft (fig. 3), and the regenerators R so connect the compartments that a cold space *b* communicates with a hot space *b'*, which is one-sixth of one revolution in advance. Both hemispherical

vessels are about half filled with water, whilst the other parts, as well as the regenerators and tubes, contain atmospheric air.

The air, being much lighter than the water, keeps at the top of the latter, so that with the inclined position of the vessels, the air will always, during the descending portion of the revolution of any one pair of compartments, pass from the hot spaces *b'*, which are advanced in their position, into the cold spaces *b*, whilst during the ascending part of the revolution the air passes into the hot spaces *b'*, which occupy in their turn the upper position. It is thus evident that the air passes in a cold condition downwards, and in a hot condition upwards, and that it has to pass through the regenerators each time in opposite directions. The regenerators absorb fresh heat, and give it up again in the same manner as in caloric engines of the ordinary construction. It is further evident that the hot air, owing to its expansion by heat dislodges more water than the cold air does, and that the difference of the weights of the dislodged water during the ascent and the descent of any particular section of the vessels is the moving power of the machine. Water, allowing only a small difference of temperature, being taken in this case as a medium for producing the differences of weight which form the moving power, a small difference of the temperature only of the air, and consequently also a very insignificant moving power would be produced, if the peculiar action of the vapour of the water had not to be taken into consideration. If, for instance, the temperature of the cold vessel *a* is 132 degrees Fahr., and that of the hot vessel *a'* is 212 degrees Fahr., the air would expand only one-sixth of its volume by heating, whilst the water vapour would expand to ten times its volume, with an increase of temperature from 132 degrees to 212 degrees. Both combined would thus produce an increase of nearly double the volume. The regenerators R are therefore not only used for absorbing and supplying alternately heat from and to the air, but also for alternately condensing and regenerating the steam, this being perfectly attained with a sufficient surface of the regenerator and the presence of air as supporter of the steam, of course as long as the water does not boil.

If the hot vessel *a'* is heated so much, that the water begins to boil, the spaces *b* of the cold vessel *a* would serve as a condenser, and they would quickly be heated to the boiling point, whence every effect productive of power in the machine would cease. With the use of air and the ordinary atmospheric pressure in the system, a temperature of 212 degrees should not be reached. However, other fluids can be applied, as no losses through evaporation take place. The necessary cooling is effected by filling the hollow space D (fig. 1) with water; this space communicates with the lower ends of the cold compartments by means of the holes *e*, *e*, whilst the tube *f*, effects a similar connexion with the hot vessel. The various parts of the whole system are thus connected directly with each other as well as with the atmospheric air, whence no superpressure can be produced, the object being to remove all danger of explosion. The water evaporated in the open cooling space has to be filled up from time to time, and in this manner the whole system is provided with the necessary quantity of water. The heating of the outer (hot) vessel has to be effected by direct firing, for example, by means of an apparatus for the burning of petroleum. The regenerators R consist, as in other caloric machines, of passages filled with wire gauze, or equivalent metallic material offering a large surface.

In order to increase the power of motion, Mr. Siemens recommends the application of a specifically heavy fluid, as, for instance, mercury, in which case all parts of the machine should be made of iron. At present, Mr. Siemens' motor cannot be deemed to have attained more than an experimental stage; but it is, nevertheless, a contrivance the ingenuity of which renders it interesting.

The second exhibit of Mr. F. Siemens is a steam motor equally simple and ingenious. It consists of a casing of sheet iron A, figs. 4 and 5, which is cylindrical at one end and pear-shaped at the other. The whole is maintained in an oblique position by means of an iron support *b*, *b*. The inner portion A is free to revolve round its axis of motion *l*, *t*, while the exterior B is stationary; *d* is a second casing surrounding the lower projection of *i*, *t*, and *c* a condenser. Around the interior of A a helix, also of sheet iron, is wound so as to present

to the eye the appearance of a series of interplaced funnels. The inner surface of B is lined with fire-clay. The condenser consists or a pipe of convenient diameter encircling part of the motor a sufficient number of times. One end communicates with the upper portion of the motor, and the other with the chamber A. The space *k* between A and its second casing *d* may be called the boiler of this apparatus; it is filled with water by means of a small opening in the upper part of A. A Bunsen burner placed beneath supplies the heat, which converts the water into steam. When the steam is generated, it passes through circular orifices perforated in the under surface of A, and rises in the interior of the motor. The force with which it impinges upon the sides of the helical sheets is at first insignificant; but it gradually increases with the continued generation, and consequent pressure of steam, so as to overcome the inertia of the motor, and to impart to it a comparatively rapid movement. When the steam is circulating through the upper part of A, it enters the condenser, and is converted into water, which returns and feeds the boiler. The products of combustion escape through a flue inserted in the outward fixed casing, and which communicates with the cylindrical space B. To obtain a motive power of 60 or 70 foot-pounds it is necessary to increase the supply of heat; and for this purpose a series of Bunsen burners is employed. The movement is transmitted by means of the shaft *h*, which is connected with the axis of the motor either by bevel wheels or, in case of easy work, by a spring *g*.

When once rotating, this motor requires but very little attention. As both water and steam are confined within the revolving casing, and as there is no communication whatever between the interior and the exterior, there is but little friction, and therefore we gain power. Instead of a safety-valve, the inventor has adopted a small plug of fusible metal, which is inserted in the upper part of A. In the exhibited motor, this safety-plug was also used as a hermetical stopper for the water aperture. The only object attained by this twofold office is greater simplicity in the general mechanism.

The chief difficulty in the construction of this motor is to prevent the circulation of the water through the spiral spaces *s*, and approximately to maintain the horizontal level of the water, notwithstanding the movement of rotation. Of course absolute horizontality could not be preserved on account of the centrifugal force caused by the rotary motion, for it may easily be seen from the figures that the water revolves with the cylinder A. This inconvenience has been considerably diminished by making the spirals present extensive conical surfaces. This disposition affords a free downward passage to the water, and permits only the steam to circulate through the helices.

When the motor is constructed for maximum power, the condenser is suppressed, and a funnel-shaped vessel, providing the water supply is fitted into the upper part of A.

Mr. Siemens thinks that other fluids than water may be also advantageously used in his motor. He specially recommends oil and mercury. The latter would give more power than water on account of its greater density and lesser specific and latent heats.

The alleged advantages of this invention are the direct action of the steam, a simple mode of condensation, utilisation of the full expanstve force of the steam, and a gain of power corresponding to a diminution of friction.

Like the caloric, this motor is only the realisation of a scientific idea. It is a germ which time perhaps may develop and cause to fructify.

M. Perreaux, Paris, had a fine collection of instruments for measuring very minute dimensions and for dividing the straight line and circle with great precision. His spherometer records to the $\frac{1}{100}$th part of a millimetre. The length of the screw is 15 centimetres; its pitch $\frac{1}{4}$ of a millimetre; the diameter of the circle, 12 centimetres. The circle is divided into 500 equal parts, each of which is thus $\frac{1}{2000}$ of a millimetre; but as a free space of a millimetre is left between two consecutive divisions, the $\frac{1}{4000}$th of the millimetre is attained.

The micrometric machine of M. Perreaux is another finished piece of mechanical skill. Its object is the exact graduation of circles. The pitch of the screw is the $\frac{1}{10}$th of a millimetre. The development of the graduated circle is three metres for every movement of the screw equal to a millimetre;

with a very fine diamond, the $\frac{1}{1000}$th part of the millimetre may be accurately marked.* Several experiments have given the $\frac{1}{1500}$th of the millimetre.

M. Perreaux also exhibited a cathetometer with the most recent improvements.

The most remarkable of the optical exhibits were the lighthouse-lenses exhibited by MM. Sautter, Lemonnier, and Cie., of Paris. In the department allotted to the Maritime Government of Trieste, these gentlemen had a flash-light apparatus of the fourth order. The lamp is constructed on the Farquhar system, of which we shall speak further on, and is intended to burn mineral oil. The flashes are produced by the revolution of a series of vertically placed plano-cylindrical lenses, each of which receives a pencil of rays of 18 deg. amplitude, and concentrates it to 6 deg. By this means the divergence is evidently diminished, and the intensity of the emergent beam increased in the ratio of one to three. The lenticular cylinder revolves in front of the central lens; the upper part of the apparatus is disposed as is usual for a fixed light sufficiently intense to be distinctly visible in clear weather at a distance of at least 12 miles. The interposition and regular rotation of the movable lenses produce equidistant and very characteristic scintillations. Experiments have been made to ascertain the most convenient interval that should elapse between two successive flashes, and the conclusion arrived at is that it should not be less than a second and a half. It would appear that if they followed each other more rapidly there would be a possibility of mistaking them for the flickering or fluctuations, noticeable in certain states of the atmosphere, in fixed lights which rise but little above the sea-horizon.

A second apparatus exhibited gives flashes alternately red and green. The mechanical disposition of this beautiful model belongs to the firm already named, while the optical calculations were made by the engineers to the administration of the French lighthouses. It consists of three distinct parts, the ordinary dioptric and catadioptric lenses of the fixed light, embracing an angle of 150 deg., and a catadioptric reflector fitted up in the supplementary angle, and two series of prisms placed vertically in front of the fixed light apparatus on both sides of the axis, and beyond the angle of illumination. These elements have been so determined as to concentrate the rays emanating from the fixed light, and to diffuse them, with as much uniformity as possible, over the useful angle of 45 deg. Between the vertical prisms and the fixed light apparatus there runs a circular frame containing three glass segments of 75 deg. each. The middle one is green, and the other two red. When an intermittent oscillatory motion is imparted to the frame the flashes are produced, and, during a short but determined period, present a constant colour. The whole apparatus is mounted upon an iron stand, which encloses a machine that imparts a uniform rotation to a vertical axle. The uniformity of motion is attained by means of one of Foucault's regulators. This vertical axis carries a horizontal plate with two grooved arcs of different radii, concentric with the vertical axis, and communicating with each other by means of sinuous lines. A little roller, attached to the oscillating support, fits into these arcs, and remains motionless as long as it is in the circular groove; but as soon as the rotation of the axle brings it into contact with the sinuous lines, it moves over to the opposite arc, where it remains for a brief space of time, and then recommences its curvilinear course. In this way the frame describes an arc of 75 deg. in four seconds, and remains motionless for the next sixteen. By this motion the coloured glasses pass successively before the various parts of the apparatus, and thus produce their characteristic light.

In the French section of the Machinery Hall, MM. Sautter and Lemonnier exhibited an electric light apparatus of the third order. The current was furnished by a Gramme machine about 80 ft. distant, and with satisfactory results. The chief feature in this apparatus is the size of the lens. For fixed lights an 11·8 in. is generally used, but here we have one 29·5 in. in diameter. This departure from long-established custom appears to be fully justified by three important advantages. Firstly, because it is highly probable that very strong magneto-electric currents, such as those developed by the Gramme and the improved Alliance machine, will be extensively used

for lighthouse purposes, in which case it is obvious that the preservation of the holophotes will require them to be more distant from the incandescent carbons; secondly, because this system is much more convenient for the keeper; and, thirdly, because a large lens will proportionately diminish the variations in the direction of the emergent rays caused by the inevitable changes in the position of the radiant point. The lens of the apparatus which we are describing, is cylindrical, the interior diameter being 29·5 in. It is provided with upper and lower catadioptric zones. The supports of the central piece are not upright; they wind around the glass cylinder in the form of a spiral. The object attained by this obliquity is that, to an observer, only one point in any vertical or horizontal plane is involved in darkness. A lenticular polygon, consisting of 24 vertically placed plano-cylindrical lenses, is set in motion by clockwork. Each lens receives a beam 15 degrees in amplitude, and concentrates it to 5 degrees. The polygon completes a revolution in 120 seconds, so that the interval between the flashes does not exceed five seconds. The duration of the flash is but half that of the fixed light of minimum intensity, which remains visible between two successive flashes, while its intensity is eight times greater. These numbers still hold, whatever the interval may be; if the latter be increased the absolute duration of the flash is increased just in the same proportion.

It may here be pertinent to remark that when oil lamps are used the flashes are of shorter duration, and it is customary to remedy this inconvenience by increasing the diameter of the lamp. This drawback does not exist in the electrical apparatus just described, as the divergence is caused not by the size of the luminous body, but by the form of the lens. Moreover, this divergence occurs only in the horizontal plane, whence it follows that the beam losses none of its luminosity.

The regulator used is of Serrin's construction. It is placed on a circular metallic table, whose geometrical centre does not correspond with its centre of rotation. Two lamps are provided, so that when it becomes necessary to change the carbons, the extinction of the light is only momentary. This is readily effected by turning the eccentric table, when one of the lamps is thrown out of focus and the second is brought into circuit. The cost of this apparatus is 1,200*l.*

The same firm also exhibited an apparatus for the projection of electric light, which may render valuable service in several departments, especially in our merchant navy. If our ships were provided with brilliant head-lights, it is probable that catastrophes would be of much rarer occurrence that they actually are. Up to the present there has been considerable difficulty in the way, the size and prime cost of the Alliance machine rendering it difficult for general use. But since the Gramme has afforded a more approximate solution to the question of cheap electricity, it is probable that the great advantages of the electric light will eventually secure its adoption. The pecuniary consideration is no doubt an urgent recommendation in favour of the comparatively new apparatus; but it is also well to remark that its very construction renders it suitable as a machine to guide our vessels on their pathless way through the darkness of the night and the dense fogs that are often impervious to the rays of the sun. It is compact and solid. There is no delicate mechanism that might be disordered by the rolling and pitching of a storm-beaten vessel. The whole occupies but little space and may easily be connected with the machinery. The optical apparatus consists of a holophote—Fresnel system—enclosed within a cylinder of sheet copper, open at one end for the projection of the parallelised rays, and closed at the other by a small door of the same material. The cylinder is susceptible of two motions, one in the horizontal plane of 360 deg. amplitude, and the other in the vertical plane of a range limited only by convenience. The details are disposed in such a manner that as soon as the regulator is introduced the circuit is complete. The steadiness of the light is not affected by the movements of the oscillating cylinders. The cost of the holophote, including the regulator, is 150*l.*

Among several other objects of interest which we remarked in this collection we should mention the exhibition of improved lighthouse lamps. The chief modifications have been introduced by Farquhar, and are based

upon this principle that, to facilitate combustion, it is of great importance that the air should have the same velocity throughout the different parts of the flame, and that the parallel strata of air and combustible gas which find their way out through the chimney should be as thin as possible. These conditions are not fulfilled in the burners which are in general use in light-houses. The air finds a readier outlet in some parts of the lamp than in others; for example, the free space between the chimney and the exterior cylinder being wider, the air circulates more easily than in the cylindrical space in the centre, or even in the intermediate annular spaces. Besides, the lower aperture of the former is not on a level with the apertures of the latter; and hence a difference in the rapidity with which the air circulates through these various passages. As the velocity is always greater in the exterior portions of the burner than in the centre, it follows that the exterior flame never attains the same degree of development as the others. These defects have been removed by surrounding the exterior wick with a cylinder which is concentric with the exterior cylinder of the burner itself; its lower opening is exactly on a level with that of the others, and the annular distance between it and the exterior cylinder is precisely similar to the other annular spaces. A similar cylinder is also placed in the centre of the interior burner. The chimney moves on the draft-tube in such a manner as to force the air to find its way through the annular spaces, and, as it meets everywhere the same resistance, its velocity is uniform throughout. In burners destined for the consumption of mineral oils, the exterior ring is a little higher than the others; and besides, there is in the draft-tubes, a slight widening towards the upper part, whilst there is a similar contraction in the space destined to receive the wick. The modifications which we have just enumerated insure an equal distribution of air within the flame, whilst all the concentric rings are in perfectly similar conditions of combustion.

There was in the Exhibition a series of these burners with 2, 3, 4, 5, and 6 wicks for vegetable or animal oils, and another series for mineral oils. The luminous intensities have been photometrically determined, the standard being a Carcel burning 1¼ ounces of colza per hour :—

	Colza.	Paraffine.
With 2 wicks - -	6	6
„ 3 „ - -	16	16
„ 4 „ - -	from 30 to 35	from 28 to 32
„ 5 „ - -	„ 40 „ 50	„ 40 „ 44
„ 6 „ - -	„ 60 „ 75	„ 55 „ 65

The higher numbers in the last three lines indicate the maximum intensities that may be reached without rendering the flame smoky; the other numbers represent the normal intensities at which the light may be easily maintained. A Farquhar burner, fed with colza, preserved its brilliancy unchanged during an experiment that lasted 16 hours.

The framework of the compartment in which these burners were exhibited was hung with full-sized photographs of the flames emitted by these lamps.

The most attractive collection in Group XIV. of the British section was that of the distinguished firm of Siemens Brothers. The exhibits were varied and highly interesting, both from a theoretical and practical point of view. They included telegraph apparatus and materials, electric alarums, lightning dischargers, deep-sea thermometers, pneumatic signal apparatus, submarine cable specimens, &c.

The insulators which were exhibited are of porcelain, as experience in various countries has shown that this material is superior in point of durability to glass, ebonite, stone, or india-rubber. The porcelain cup is cemented in a cast-iron bell, provided with a flange for the purpose of fastening the insulator to the post. This is done by means of wooden screws. Inside the cup there is a wrought-iron stalk, terminating in notches, within which the line-wire is placed and firmly secured. These insulators are either painted with black varnish or galvanised. The latter is preferable. The telegraph posts are all on the iron tubular system, devised by Dr. Siemens. The prime cost is

certainly greater than that of wooden posts; but ultimately they are found to be quite as cheap, if not cheaper. A wooden post in general, under favourable circumstances, does not last more than five or six years, whereas an iron one will probably last for half a century. Each post consists of four parts, a buckled foot-plate of wrought iron bent in the form of a dish, a wrought or cast-iron tube, a conical wrought-iron welded tube, and a lightning discharger. The footplate is fixed by means of four bolts to the iron tube which forms the lower part of the post. This terminates in a socket into which the conical tube is cemented. The lightning discharger is fastened in the top of this conical tube, in order to protect the line against the effects of atmospheric electricity. The pole rises 16 ft. above the ground and weighs 1¼ cwt., that is half the weight of an ordinary timber pole of equal height. These posts have been used on the lines constructed for the British Government through Mesopotamia, Persia, Ceylon, and various parts of the East Indies. They are also employed in Spain, Egypt, South Africa, Russia, and even in Mexico, Brazil, Peru, and La Plata. Indeed, their intrinsic merits as well as economical considerations, urge their universal adoption.

Siemens Brothers also exhibited a great variety of telegraph wires—galvanised iron and copper wire insulated with india-rubber or gutta-percha—for all kinds of submarine lines and river crossings, as well as for mining and military purposes. There were also samples of several cables, including the Mediterranean, the Kertch, Hong Kong, and Shanghai, La Plata and Brazil, and the transatlantic cable laid between Plymouth (England) and Halifax (Nova Scotia). The conducting core of the last consists of seven copper wires, and the length is about 3,060 miles.

There were several other exhibits in this collection of particular interest, and to which we may call special attention. The first is the mine and torpedo exploding apparatus, better known as Siemen's dynamo-electric apparatus. This is a small magneto-electric machine shown in fig. 6. It differs from those formerly made in the substitution of electro for permanent magnets. The armature A is a cylinder of soft iron round which a number of convolutions of insulated copper wire are wound transversely, and which is made to rotate between the poles of an electro-magnet. This magnet has been made once for all by transmitting around it a voltaic current, the residual magnetism sufficing to obtain a proper action of the apparatus on subsequent occasions. The remanent magnetism is, of course, very weak, but a powerful magnetisation is soon built up by an application of that beautiful and highly useful principle of simultaneous electrical action. The feeble current at first developed in the revolving armature is sent round the soft-iron cores, thus increasing their intensity. This new increment now reacts upon the armature and induces a stronger current, which, in its turn, proportionally raises the magnetic condition of the iron. This process continuing, a powerful battery is soon formed; indeed, after a few revolutions the magnetic capacity of the core has attained its maximum.

The induced currents are instantaneous and alternately in opposite directions. Hence the adoption of a commutator, C. As shown in fig. 6 the coils of the armature and those of the electro-magnets are in short circuit; but this is interrupted automatically by the mechanism D, S, R^1. D is a lever which establishes the short circuit, and which also breaks it by means of the under projection T. R^1 is a wheel revolving on the same axle as R; T works into the notches of the cam, impelled partly by its own weight, but chiefly by the superposed spring P. When it has fallen into one of the indentations, the metallic piece O comes in contact with the lower screw M, and the current passes through the interpolar wire fastened to the two terminals *e* and e^1. The apparatus is inclosed within a box, the two binding screws only being visible, as they are fixed on the outside of the case. The wires leading to the mine or torpedo should, for prudential reasons, be connected with the apparatus only when the fuse is to be fired. It is clear that the leading wires should be perfectly insulated from one another. It is not absolutely necessary that there should be two wires; but if one be dispensed with care must be taken to establish good earth connexion. It is also advisable, to prevent misfire, to use two or three of Abel's fuses in each mine that is to be sprung,

and to connect them so that the current must pass through them all in succession. It must be obvious that several charges of powder, or several mines may be exploded simultaneously. A moment's reflection will suggest the proper connexions to secure immediate ignition. This apparatus is extensively used at Woolwich and Chatham.

The second exhibit to which we referred above is the electrical pyrometer of Dr. C. W. Siemens. Mercury is admirably adapted, both by the purity with which it may be obtained and it sensitiveness to very small increments of heat, to register temperatures varying from — 39 deg. Fahr. to 660 deg. Fahr., that is to say, from the freezing to the boiling point of the metal itself. Ingenuity has devised thermometers which record with precision degrees of cold far below — 39 deg.; but we cannot say the same of most of the pyrometers hitherto adopted; in many cases they have read with considerable inaccuracy the temperature of the oven or blast furnace in which they had been placed.

Every reader of Dr. Lardner's popular works must occasionally have met with statements referring to very high temperatures, and must have remained not a little dissatisfied at the omission of the means by which such extraordinary data had been ascertained. The pyrometers which gave such results must have been very imperfect, since it can now be proved, as Dr. Siemens says in the paper which he read before the Royal Society on his new invention, that the highest temperature obtained by the combustion of carbon with a blast of atmospheric air cannot exceed 4,600 deg. Fahr., which degree is beyond the greatest temperatures required in metallurgical processes. We believe the numbers given by Lardner were recorded by a Wedgewood's pyrometer. Now every tyro in physical science knows that the principle upon which this instrument is based is the property peculiar to fire-clay, by which it contracts when exposed to heat. This contraction is caused by the expulsion of the water of hydration, and it has been assumed that this expulsion is proportional to the temperature. This assumption is proved to be incorrect.

The principle involved in Siemens' pyrometer is exceedingly simple—it may be found in elementary treatises on electricity, viz., that the resistance of a pure metallic conductor increases with its temperature. This increase is not uniform; it follows a parabolic law which has been carefully studied and accurately determined. Therefore, given the resistance of any conductor at 0 deg. Cent., we may calculate what it would be at 100 deg., 1,000 deg., or 3,000 deg. Reciprocally, knowing the resistance, we may at once infer the temperature.

The metallic conductor used is a fine platinum wire of known resistance. It is coiled on a cylinder of fire-clay upon which a helical groove has been cut to insulate each convolution of the wire. This clay cylinder, which is about 3 in. long, and ½ in. in diameter, is enclosed within a casing, the lower part of which is conical in shape, and is made of platinum, copper, or iron, according to the temperature which has to be ascertained. The two ends of the platinum coil are fixed within this projecting tube to thicker copper wires carefully insulated. These are led to the galvanometric apparatus, which may be either a differential galvanometer or a "differential voltameter," according as the case may require. The manner in which the electrical resistance is measured by the former instrument resembles that of Wheatstone's bridge. This will be understood from fig. 7. The current from the battery B divides at the metallic slide or index-lever C, one portion going to D and the other to E. Here these partial currents again divide, one part proceeding through the galvanometer and the other through the binding screw N, and the pyrometrical wire M, to the screws O and P, where it meets the portion from E that has passed through the constant resistance R; thence it returns to the battery. If the branches E, P, and D, N, M, O, offer equal resistances to the current, the galvanometer will not be affected; but if one of these present a greater resistance, the needle will be accordingly deflected. The needle is then brought back to zero by shifting the slide C. When the electrical balance is restored, the increased resistance of the platinum spiral is determined, and the temperature may be reckoned by finding on the table of reference, which accompanies each instrument, the number corresponding to

that indicated by the graduated arc. Many of these pyrometers register temperatures of 2,250 deg. Fahr. and some as high as 4,500 deg. Fahr.

A characteristic and precious feature of this instrument is that it offers facilities for ascertaining the temperatures of places distant or difficult of access, or even inaccessible, since the indicating part of the pyrometer may be 3 or 300 yards away from the metallic coil. It may thus be applied to determine the temperatures of cables rolled up in the hold of a vessel—and this is very important if we consider that a cable may be destroyed by a spontaneous generation of heat—of stores of combustible materials, of points situated far above or below the earth's surface. It will be found an invaluable instrument in a colliery or in iron works, as it will enable the proprietor to know exactly the degree of heat in his mine or his furnace; a serviceable apparatus in gas works, since the lighting qualities of the gas is influenced by the temperature at which the coal is distilled. It must also be a valuable acquisition to the man of science, since without leaving his room, without exposing himself to the inclemency of the weather, he may read the temperature of an elevated place or a deep stratum, a lake, or an ocean. Professor Bolzani used this pyrometer in his researches on the temperature of points situated considerably above or below the earth's surface, and Mr. Lowthian Bell in his investigations of blast furnace economy. Dr. Carpenter used a slightly modified form in his deep-sea soundings; and it is with the same that the Challenger is making a more elaborate study of one of the most interesting problems in hydrography, the temperature of the Atlantic at various depths.

In all these cases, long leading wires are required, and as both branches of the galvanic circuit might not be equally affected by these additional lengths, a door would be here opened to errors, which might materially influence the reliability of the observation. But by an ingenious device, this source of inaccuracy is completely avoided. A third leading wire is provided; and by this means one of the partial currents mentioned above passes from the battery through one of the leading wires to the pyrometrical spiral, and thence through the second leading wire, the galvanometer or voltameter, as the case may be, to the battery. The second partial current circulates through the constant resistance and the third leading wire up to the platinum coil, whence it returns by the second leading wire to the galvanometer and battery. Thus both branches of the circuit consist of an equal length of the conducting wires, and all their variations of resistance, caused by the changes of temperature, affect both sides of the balance equally.

It might appear from *à priori* considerations that the conductivity of the platinum must be permanently altered by frequent exposure to intense heat; but Dr. Siemens has ascertained, by a protracted series of experiments, that for a given degree of heat the electrical conducitivity of a metal—apart the the changes occasioned by oxidation—is a constant quantity. Iron and copper readily oxidise, and thus increase their resistance, rendering their readings unreliable. But this is not the case with platinum; it remains materially unchanged, except when directly exposed to extremely high temperatures. Then it volatilises; but by inclosing the spiral within a platinum envelope, the former receives only radiant heat, and as four or five minutes suffice to give a correct reading, temperatures approaching the point of fusion of platinum may be readily measured.

The second apparatus for measuring the electrical resistance is the "differential voltameter." This beautiful piece of ingenuity is shown in fig. 8. It consists of two calibrated tubes about $\frac{3}{25}$ in. in diameter, fixed upon a scale divided into a number of equal but arbitrary parts. The upper ends are closed by india-rubber cushions retained in their positions by weighted levers; the lower ones are widened out and closed by wooden pegs, perforated to admit the two electrodes. Two glass reservoirs, containing acidulated water, are in communication with these widened parts by means of two pieces of india-rubber tubing. By closing the upper ends and moving the reservoirs in their vertical slide, the fluid rises in the tubes by the law of communicating vessels, until its surface is in the same horizontal plane in the reservoirs and the tubes.

The battery current, as we said before, is divided into two circuits, one of which comprises a known resistance, the leading wires up to the pyrometer, and one of the tubes; the other includes the leading wires, platinum spiral, and the second voltametric tube. The measurement of the resistance is based upon two well-known laws, one of Faraday and the other of Ohm. Faraday showed that the volume V, of gases liberated in a voltameter in any multiple or fraction of an assumed unit of time, T, is proportional to the strength, S, of the current.

That is $V = ST$. Therefore $S = \frac{V}{T}$.

But Ohm has proved that the strength of a current is directly proportional to the electro-motive force and inversely as the resistance. That is $S = \frac{E}{R}$. By equality of ratios we have $\frac{V}{T} = \frac{E}{R}$. Multiplying by T, we find $V = \frac{ET}{R}$, or the volume of mixed gases evolved in each of the tubes is directly as the electro-motive force and the time, and inversely as the resistance. There are here two elements of inaccuracy; the electro-motive force and the time. The electro-motive force is liable to continual variations from polarisation, temperature, and concentration of acids; and as to the time, it is difficult in most cases to make observations with exactness. It was then necessary to remove these elements of inaccuracy before the formula could be of any practical use. This was done by adding the second voltametric tube and dividing the current into two distinct circuits, as above described. If we call V^1 the volume of gases collected in the second voltameter, and R^1 the resistance of the circuit, we shall have, by Ohm's law,

$$V^1 = \frac{ET}{R^1}.$$

But we have shown that

$$V = \frac{ET}{R};$$

therefore

$$V : V^1 :: \frac{ET}{R} : \frac{ET}{R^1} :: \frac{1}{R} : \frac{1}{R^1} :: R^1 : R.$$

Solving for R^1 the required resistance, we have

$$R^1 = R \times \frac{V}{V^1}.$$

That is the resistance of the pyrometric spiral is equal to a constant R, multiplied by the ratio of the volumes of the gases produced in the tubes. This formula, as apparent, is independent of electro-motive force, time, and temperature. The only source of error that might now remain is the fire-clay itself, its insulating properties diminishing when once a certain limit of temperature is reached. This, however, is slight, and is practically negligable.

The acidulated water should contain 10 per cent. of sulphuric acid. Care is required in selecting the platinum for the coil, as samples have been found conducting 4·7 times better than mercury at 0 deg. Centigrade, whilst the conductivity of others from the same establishment was 8·2.

The manner of operating with the pyrometer is this:—Adjust the level in the tubes as before directed; place the conical part of the long protecting cylinder in the furnace whose temperature is to be ascertained; turn the commutator so as to make connexion with the battery; reverse the current several times during the observation, so as to prevent an unequal polarisation of the electrodes; cut off the current when the dilute acid has fallen about 40 divisions in the less activated tube, and read off the levels of the liquids on the scales marked V and V^1. Referring to the Table, find these numbers in the columns marked V and V^1; and at the intersection of two imaginary lines, drawn from these numbers, the resistance of the spiral and the corresponding temperature of the furnace will be found marked respectively in black and red figures.

The number of the pyrometer which we examined in the Exhibition is 413, the constant resistance is 17 Siemens' units, and the resistance of the platinum wire at 0 deg. Centigrade is 10 of the same units.

Another highly interesting exhibit in this collection was the apparatus illustrative of the working of the electric block system. This is an important and very efficient application of electricity. At all times it has been a subject of investigation for telegraph engineers to devise a method of signalling which, with a maximum of simplicity and solidity in its construction, would insure the greatest amount of security. The ordinary block system was the nearest approximation to the fulfilment of these conditions; but the modification which has been recently introduced is certainly a great step towards the complete solution of the problem. The electric block system has already been introduced into several parts of Germany. Its leading features will be understood from the following rapid sketch. Let the letters A and D represent two consecutive stations, B and C their respective signal-boxes. When the train leaves the station A, the operator announces its departure by ringing the bell of B, and at the same time blocking the intervening portion of the line, that is, he turns up a red disc or shutter in the optical part of his apparatus. When the train reaches B the operator rings the bell of C, and then blocks the line between B and C; that is, he first lowers his arm and then turns up a red disc in his apparatus, making, by a simultaneous and mutually dependent action, that of A white. It is well to notice that he must first bring down his arm before he can give any signal at all. It is plain that this is a very valuable control. The signalman at B is now able to restore to its horizontal position his arm, which must remain down, until the red is replaced by the white disc. The reason and advantage of this must be obvious. When the train arrives at C, it must there wait until the station signals that the line is free.

The currents used are magneto-electric, obtained by turning a handle carrying on a horizontal axis an armature that rotates between the poles of permanent magnets. The positive and negative currents are both required to change the discs, but one only—the positive—is transmitted to ring the bells. There is only one conducting wire.

The Electrical Department in the Vienna Exhibition may emphatically be said to have borne the stamp of the age. The attractions of fortune seem to have had more charms for the electrical genius than the prestige of fame; and accordingly the instruments of theoretical research were comparatively few, while those destined for practical purposes numbered legion. There was an endless variety of telegraphic apparatus. The Morse and the Hughes occupied conspicuous positions in every collection. It would seem as though the minds of instrument makers had been on tenter-hooks to devise every possible modification, and it cannot be denied that several very useful improvements—affecting principally the ease and rapidity of transmission—have been introduced. This general attention has resulted not only in improvements; in several instances it has produced new and valuable instruments. The beautiful idea of Caselli has not been neglected, and the autographic apparatus of Arlincourt and Meyer are marvels of ingenuity. The requirements of military telegraphy have produced a little instrument which has many merits to recommend it. This is Breguet's military telegraph, and is identical with his exploder, an account of which will be found further on.

The Vienna Exhibition showed that the tendency to the disuse of galvanism is not confined to the arts, but finds its way to the lecture room. There are but few samples of voltaic batteries; and the most remarkable of these, by the novelty of its leading features, in the secondary battery of M. Gaston Planté. It is well known that the strength of a current of polarisation depends upon the metal which produces it. M. Planté has shown that this current attains its maximum energy when the plates used are of lead. Each element of this new battery (fig. 9) consists of two long plates of this metal, wound into a spiral, immersed in acidulated water and separated from each other by india-rubber bands, C, C^1. It is charged by connecting the electrodes of two Bunsen cells with the binding-screws G and H. A and A^1 are the two terminals of which A_1 is permanently connected with G by means of the

copper strip M_1, whilst A is made to communicate with H by the spring R, the button B, and the metallic band M. As soon as the circuit is complete, the water is decomposed, and binoxide of lead is formed at the positive plate. By its affinity for hydrogen, the binoxide introduces a force which tends to oppose the electrolytic action, and which finally stops the process of decomposition. On connecting the terminals a current will now be produced considerably stronger than the primary one. When several of these elements are to be formed into a battery, they are coupled as shown in fig. 10. During the charging process, they are to be arranged for quantity, while during the discharge, they may be coupled either for quantity or tension. These ends are attained by means of a special commutator. It consists of two cylinders, C and C^1 (fig. 10), one o fwhich connects, by small springs, the even and the other the odd poles of the same couple. These two cylinders are separated by a rod of some insulating material, which carries on its upper surface a corresponding number of copper strips placed transversely. By revolving the discs of the rod, these strips are brought into contact with the springs, and in this manner with the elements of the secondary couples, connecting them during one portion of a revolution for quantity and during the next for tension. I and I^1 are the battery binding-screws. The charging current develops an opposite electro-motive force in each of the secondary couples equal to once that of a Grove cell, or one and a half times that of a Bunsen. With two plates, each having a double surface of 21 square feet, effects have been obtained equal to a Bunsen battery of 70 small size elements. The time necessary to impart, with two Bunsen cells, a maximum charge to a secondary couple varies with the dimensions of the plates, from 8 to 10 minutes, whilst the duration of the discharge varies from 1 to 8 or 10 minutes. This battery may be used for electric light experiments with powerful induction coils, for diamagnetism, and in general whenever a strong quantitative or tensional current is required. It is made by M. Breguet, and is nearly as expensive as a Grove of equal intensity.

Besides this new battery, and competing with it for the prize of success, were the latest forms of the magneto-electric apparatus. There was especially a small Gramme machine (fig. 11), which appeared to give very good results. There is only one coil A, M_1, B, constructed on the principle of that in the larger machine, which we shall explain a little further on. No electro-magnets, however, are used. The poles N and S of the steel magnets are placed in the same vertical plane. The strength of the current evidently depends on the quality of the steel, which also influences the price of the apparatus. It is probable that the common horse-shoe magnets will be ultimately replaced by Jamin's magnet, a recent improvement of considerable value. This modification would be attended by an augmentation of the intensity of the current, and also, if we are rightly informed, by a decrease in the prime cost.

The Alliance Company also construct small models of their apparatus for educational and other purposes. One containing eight bobbins will be found very serviceable when comparatively weak currents will suffice. It seems especially intended as a substitute for a dynamic battery of a large number of elements. The solidity of its construction shows that it is prepared for the roughest work of the laboratory. There is a third type, which contains only four bobbins, and is mainly intended for the lecture-room. We may add that it has already been used with success in several mining and torpedo experiments. On one occasion, eight fuzes were simultaneously fired at a distance of 290 ft.

A very interesting collection of contrivances for exploding mines and torpedoes was exhibited by Mahler and Eschenbacher. There was a primitive exploder—the galvanic battery—formerly used in the Prussian army for springing mines; also that of Baron Ebner, identical in principle with the Leyden jar. The electricity is generated by the action of metallised rubbers against two circular plates of ebonite, and stored up until it has sufficient tension to overcome a determined resistance. The condenser consists of a long sheet of india-rubber coated on both sides with tinfoil and rolled up into a cylinder for greater compactness. One coating is in connexion with the earth, while

the other is clamped to the wire leading to the fuze. The free end of this wire is attached to an earth-plate. When the charge on the coatings of the condenser has attained the required intensity, a spark passes between the two ends of the wire imbedded within the fuze, and the explosive material is ignited. This apparatus, simple in principle, is equally so in its mechanical arrangements. It is but little affected by atmospheric variations.

Close by this was Siemens' dynamo-electric apparatus, described above, and which, for simplicity of arrangement and detail, for solidity and portability, is scarcely equalled by any other, save, perhaps, by that of M. Breguet, fig. 12. This latter is a magneto-electric exploder, consisting of several superposed steel magnets with their poles in the same horizontal plane. Two cylindrical pieces of soft iron are screwed into the branches of the magnets, and carry the coils of insulated wire in which the useful current is generated. The ends of the coils are in connexion with two binding screws, destined to receive the leading wires. The armature A of the magnet is susceptible of a movement of limited amplitude on a horizontal axis. In the ordinary condition of the apparatus it is kept in contact with the poles by a spring. By means of a lever-handle, B*a*, terminating in a circular disc or button, it may be suddenly withdrawn from the poles. The current is generated in the following manner. The effect of breaking contact is to displace the poles. By suspending a needle in the magnetic field it may easily be shown that when the armature is withdrawn the poles advance towards the ends of the soft-iron cylinders, and when it is restored they recede, that is, they return to their former position. A little reflection will show the resemblance—not to say identity—of this with the original experiment by which Faraday discovered magneto-electric induction, the advance and recession exactly corresponding with the introduction of the pole of a magnet within a hollow coil, and its withdrawal therefrom. The displacement of the poles, therefore, gives rise to induced currents, which may be utilized in the ordinary way. A more sudden or rapid movement insures a more intense current. Hence, if two currents of unequal strength be required, all that is necessary to be done is to move the armature more rapidly in one direction than in the other.

The magneto current developed is very weak, as may be readily shown by its physiological effects; but this drawback is remedied by a little piece of mechanism which permits the transmission of the extra-current. The two ends of the coils terminate respectively in a small screw projecting vertically downwards, and in a thin metallic strip which is fixed to the handle of the armature, and which presses against the screw when the latter is in its normal condition, thus short-circuiting the current. As soon as the armature is withdrawn from the poles, this connexion is interrupted, and the extra current passes through the interpolar wires to the fuze. As a preventive against accidents, the armature is secured by a bolt, which is drawn only at the moment the mine is to be fired. We have already stated that this apparatus may be conveniently used as a signal-key for telegraphic purposes. The receiver must be a Morse specially adapted. When the armature is withdrawn, that of the receiver leaves its position of rest and brings the ink-pad in contact with the moving paper. The inker marks as long as the movement of the armature continues. When this is again brought into contact with the magnet, the new current returns the armature of the receiver to its place, and detaches the inker from the paper. The dot and the dash are thus produced by a shorter and a longer continuance of the movement of the armature. The working of this apparatus is highly satisfactory, and it would be difficult to obtain a simpler manipulator. From its great simplicity, it may be advantageously used for field purposes, in which the power of dispensing with a battery is a great advantage.

The exploder has a resistance of about 2,000 Siemens' units. A long circuit may, therefore, be used without sensibly diminishing its effects. In 1868, several fuzes in Rouen were fired from Paris, the distance being 75 miles. The telegraph line was used on this occasion; the earth performing the office of return wire. In the beginning of 1869, a similar experiment was made between Paris and Bordeaux, a distance of 362 miles. These trials

showed a superiority in Abel's fuzes over those of Ebner. M. Breguet asserts that the former are the most sensitive that have been hitherto employed. A collection of these fuzes was exhibited by Mr. W. Ladd in the same compartment with the exploding apparatus. The collection included fuzes and detonators for engineer operations, for submarine mines, and for mines and field work. There were sections showing the position of gun-cotton charges for mining and quarrying, for submarine blasting, and for torpedoes. It will be remembered that in 100 parts of the explosive material there are—

64 of the sub-sulphide of copper.
22 „ chlorate of potassium.
14 „ sub-phosphide of copper.

In another part of the Exhibition, there was a small case of other electric fuzes and detonators. They are those invented by Captain A. McEvoy, of the London Ordnance Works. Some of the fuzes are remarkably simple in construction. On the edges of a small circular disc formed of a hard insulating compound, are placed two thin strips of brass-foil bent into loops for the convenience of connexion. Those which are to receive the wires leading to the battery are maintained in their position by another disc of the same material as the former, and exactly equal to it in diameter. This has a cylindrical perforation through the middle, to admit the priming powder. When the latter has been put in, the insulating substance which was cut away to form the priming chamber is replaced, pressed into its place, and finally sealed with a layer of shellac. The two loops are either within a millimetre or so from each other, or are in electrical communication by a very thin platinum wire, according as the fuze is intended for quantity or tension. In the latter case, a magneto spark passes between the two terminals and fires the fuze; in the former, ignition is obtained by the fusion of the platinum.

The detonator consists of a cylinder of another insulating substance through which pass two tinned-copper wires. The upper ends of these conductors are filed level with the insulator, and are in contact with the explosive compound, generally fulminate of mercury, contained in the superior part of a long copper cap, secured to the surface of the insulating cylinder by a coating of shellac. As soon as the current passes, the copper envelope bursts with a loud detonation.

Near these were suspended three torpedoes, which are also on Captain McEvoys's patent. They are the floating torpedo, the electric spar, and electric torpedo with gravity and mercurial circuit-closer. The first is a mechanical torpedo; the manner in which it is fired is very ingenious. It is hung from a buoy by a metal rod and sent adrift. As long as it goes down the stream it does not explode; but when its progress is impeded by an obstacle, a vessel, a pontoon bridge, a barrel-pier, &c., the strength of the current turns it into such a position that the water acting on the blades of a little paddle-wheel, sets it in motion. After a certain number of revolutions it has unscrewed itself; one end of a lever is then liberated, and a piece of mechanism, resembling the trigger of an ordinary pistol, strikes a sharp blow upon a piece of steel, which transmits the shock to a small percussion cap within the torpedo. The second derives its distinctive appellation from being carried at the end of a spar, projecting from the bows of a small propeller When it is driven against a vessel a metallic ring is pressed back by the force of the blow, and comes into contact with two screws, which are the terminals of the battery. The circuit is thus closed by the vessel herself, and the torpedo bursts, scattering destruction around. In the third exhibit, the current is completed either by a gravity or a mercury circuit-closer. The former consists of a conical weight, which rests on the bottom of a cylinder. Its stability will, of course, depend upon the position of its centre of gravity, and this may be varied according to circumstances. A little spindle, pressed upwards by a spring of determined elasticity, is held down by the superincumbent conical weight so long as this retains its normal vertical position The lower end of the spindle carries a small transverse slip of brass for the purpose of connecting two tongues of metal, which are constantly in electrical communication with the battery. When the torpedo is struck the weight is tilted over to one side; the spindle is thrust up by the underlying spring

which carries with it the metallic piece and closes the circuit. The torpedo is divided into four compartments. The uppermost is filled with air for the purpose of buoyancy. The second which runs down through the middle contains the circuit-closer; the third and fourth are the powder chambers, situated on either side of the circuit-closer. When the electric current passes it fires the fuze and the surrounding priming, which last bursts through the interposed metallic partition and ignites the main charge.

The principle of the mercurial circuit-closer is similar to this. The mercury is contained in a cup of vulcanite, in the bottom of which is inserted a metal pin in permanent connexion with one pole of the battery, the cover of the cup being in communication with the other. When the torpedo is struck it is canted to one side; the mercury then flows out through a narrow opening, and as soon as it touches the metallic cap the torpedo is fired.

Captain McEvoy has also devised several ingenious appliances for connecting wires and cables. Though especially intended for torpedoes these jointers may be advantageously used for telegraphic purposes generally. The main object is to secure good contact and to relieve the core from all strain. This is attained either by twisting or soldering the ruptured wires together, or by passing them through metal discs and overlapping a small portion of them. These two surfaces are then brought together and pressed into close contact by screws from both ends. There are various sizes of these jointers, according to the uses for which they are intended. Some are constructed capable of bearing a pressure of 8 cwt. Such jointers are not only convenient for connecting wires and cables, they also save a great deal of time and trouble, in which respect, no less than in point of solidity and efficiency they may yet prove a satisfactory substitute for the long and tedious process of splicing as now-a-days practised. Captain McEvoy's jointers carry with them their own recommendation.

One of the most interesting of M. Breguet's many exhibits was a large magnet, made on the novel principle lately enunciated by M. Jamin, professor in the Polytechnic School of Paris. It has been the object of long and careful researches to determine the most effective disposition and quality of material to give to a permanent magnet. Many specimens have been made, and several theories, more or less plausible and complete, have been propounded to explain the observed phenomena. These were often but barren hypotheses, which supplied but little information about the construction of magnets. The application of voltaic electricity to magnetism, while it afforded magnets of indefinite power, turned attention way from the earlier forms; but the very progress of electrical science partly restored it to its original groove, and compelled to new investigations; for as soon as magneto-electric machines were invented steel magnets of great strength became indispensable. To M. Jamin belongs the merit of having been one of the most ardent toilers in this half-explored field, and of having satisfactorily grappled with the question. His labours are highly appreciated by practical men; and, though not yet completed, have brought a fair contribution to our knowledge of magnets and magnetism.

M. Jamin was gradually led to his discovery by studying the distribution of magnetism in thin slips or ribbons of steel. It is well known, by the labours of Coulomb and Biot that the magnetic intensity may be represented by the ordinates to a curve, and it was the properties of this curve that seem to have engaged the attention of M. Jamin. He observed that, according as he superposed his ribbons of steel, the curvature diminished, and that when a certain number had been added it entirely disappeared, being replaced by a straight line. The magnet thus formed had reached a maximum degree of strength, and was therefore called *normal*.

This very beautiful principle, which was dimly seen by Coulomb himself, greatly simplifies several complex problems in magnetism, while it affords neat and easy demonstrations of truths which have hitherto been accepted chiefly on experimental grounds. We shall presently show how it permits to express, by a formula, the total amount of magnetism in any such magnet, and also how it determines the position of the poles.

It is not easy in practice to ascertain exactly when the limit has been reached though it is doubtless a point of primary importance; nor has the

thickness of the ribbons been yet accurately determined. These deficiencies may perhaps be attributed to the newness of the subject itself, and it is probable that ulterior experiments will supplement our knowledge by precise data. However, it may be said that the number of ribbons is approximately proportional to the length of the magnet. For a length of 100 millimetres this number would be about 3 or 4, for 200 about 6 or 8, for 300 about 9 or 14. It also appears that for a given thickness there is much advantage in increasing the number of ribbons. Thus, for a thickness of 1 in. a greater effect would be obtained by using four ribbons $\frac{1}{4}$ in. each than two $\frac{1}{2}$ in.

Coulomb used, in his well-known researches on magnets, a finely-suspended needle, assuming, as his fundamental principle, that the magnetic intensity is proportional to the square of the number of oscillations made in a given time. Jamin admits this, but adopts quite a different method of ascertaining the distribution of magnetism. His criterion of intensity is the force required to overcome the attraction of a magnet for a small piece of soft iron. By applying this little contact to parts at various distances from the neutral line, the curve of intensities may be studied and graphically represented. Its equation is (1) $F = Ax^2$; in which F is the detaching force, A a coefficient varying with the length, and x the distance from the middle of the magnet. Biot's formula is the logarithmic equation

$$y = A(m^x - m^{2l-x})$$

in which y is the ordinate, x the abscissa reckoned from the austral end of the magnet, whose length is $2l$.; A and m are constants. When the needle or the strip is very long, m is a small fraction; m^{2l-x} may, therefore, be neglected, and in this case Biot's formula becomes $y = Am^x$, which bears some resemblance to that given above.

It will also be useful and interesting to examine the effect of increasing the number of ribbons. The following are the results of two sets of experiments made by M. Jamin, and recorded in the "Comptes Rendus Hebdomadaires des Séances de l'Académie des Sciences" for March 1873.

Length of Magnet, 480 *Millimetres.*

Central Distance.	Three Ribbons.	Seven Ribbons.	Nine Ribbons.	Fifteen Ribbons.
millimetres.	grammes.	grammes.	grammes.	grammes.
240	41	42·0	48·2	54·3
220	25	36·0	40·2	45·0
190	14	25·6	32·6	37·2
140	9·5	17·0	16·5	20·1
90	9·5	7·8	8·5	8·6
40	9·5	1·2	1·5	1·5

Length of Magnet, 250 *Millimetres.*

Central Distance.	Three Ribbons.	Seven Ribbons.	Eleven Ribbons.	Thirty Ribbons.
millimetres.	grammes.	grammes.	grammes.	grammes.
125	28·2	31·6	27·6	29·6
105	16·2	18·2	19·7	19·9
75	8·6	11·2	11·2	11·2
25	1·5	1·4	1·4	1·4

These tables show, first that the intensity increases with the distance from the centre, and also with the additional laminæ; secondly, that the intensity of the normal magnet depends upon its length. This last property is still more clearly shown in the two following lines, L representing the half-length and F_1 the force required to detach the iron contact:

L - -	240	200	155	125	100	50
F_1 - -	54·0	44·1	37·8	31·5	25·0	12·5

Dividing F_1 by L, we get respectively,

·225 ·220 ·244 ·252 ·250 ·250

The mean of all these is ·240, a rough estimate of what we might call the co-efficient of magnetic intensity. If we call the square root of this constant K we shall have

$$\frac{F_1}{L} = K^2.$$

Hence $F_1 = LK^2$ (2), L being the variable; this is the equation of a straight line, in which K^2 is the tangent of the angle which the line makes with the axis of X. From this we may deduce the property noticed above, viz., the approximation of the curve to a straight line. If now we suppose the x of (1) equal to the L of (2), the formula becomes $F_1 = AL^2$. By equality $AL^2 = K^2L$, and therefore

$$A = \frac{K^2L}{L^2} = \frac{K^2}{L}.$$

Substituting this value of A in the general equation, we get

$$F = \frac{K^2}{L}x^2,$$

a formula from which the value of F may in every case be readily deduced. As an example, let it be required to determine F at the extremity of a magnet 480 millimetres long. Here we have L = 240, and $x = 240$. Therefore

$$F = \frac{240 \times 240 \times \cdot 24}{240} = 57 \cdot 6.$$

By operating in a similar manner on the data given in the two preceding Tables, we shall obtain the following values for F, which do not very materially differ from those given in the last columns above,

No. 1.	No. 2.
57·6	30·0
48·4	21·1
36·1	10·8
19·6	1·2
8·1	
1·6	

To determine the total amount of magnetism, we must find the area of the triangle of intensities, and to render this formula generally applicable, we must introduce the dimensions of the ribbons, that is, we must multiply the formula by the perimeter of the magnet. Now the base of the right-angled triangle is L, and the perpendicular or last ordinate is $KL^{\frac{1}{2}}$, for the detaching force at any point being, according to Coulomb, proportional to the square of the number of oscillations, we have $F = I^2$. By equality

$$I^2 = \frac{K^2}{L}x^2,$$

and

$$\frac{K^2}{L}x^2 = K^2L,$$

when $x = L$, as in the present case. Therefore $I^2 = K^2L$, and $I = KL^{\frac{1}{2}}$ Multiplying half the base by the perpendicular, we have

$$\text{area} = K L^{\frac{1}{2}} \times \tfrac{1}{2}L = \tfrac{1}{2} K L^{\frac{3}{2}}.$$

If n represent the number of ribbons, t their thickness, b their breadth, and l their length, the perimeter will be $2(l+b+nt)$, and the formula for the total intensity will become

$$M=(l+b+nt)KL^{\frac{3}{2}}.$$

Coulomb's formula is

$$I=(mL^{\frac{1}{2}}E+nl),$$

in which I expresses the time of one oscillation, L the breadth of the magnet, E its thickness, and l half its length, m and n being two constant co-efficients for the same quality of steel.

The position of the poles may be found by finding the centre of gravity or the triangle of intensities. This will be at one-third of the line drawn from the point of bisection of the perpendicular to the opposite vertex; and if a line be drawn from this point parallel to the perpendicular, it may be shown that the pole is at a distance from the end equal to one-third of one-half the length of the magnet. Thus Coulomb's principle for short bars is applicable to the normal magnet. The magnet which was submitted to the Academy of Sciences, was constructed as follows: Two armatures, each weighing 16 kilog., are placed opposite each other, and fixed conjointly by copper bands of considerable resistance. According as they rise, the distance between them increases; they gradually become thinner, until they terminate in a sharp edge. They are 11 centimetres in breadth and 20 millimetres in transverse thickness. Their under horizontal surfaces are 12 centimetres apart. The keeper is cubical in form, and weighs 13 kilog. A magnetised strip of steel 1·20 metres long, is screwed to the outer side of the armatures, and then left free to assume the form required by its elasticity. Within this are placed other strips, which bend so as to be in contact with one another, and at the same time to press against the armatures. As the number increases, the lifting power also increases. As often observed, when magnets have been made with their keepers in contact with their poles, a greater force is necessary to effect the first separation than on subsequent occasions. The same is true of the normal magnet, as shown by the following interesting experiments, in which n represents the number of ribbons composing the magnet, F the force necessary to effect the first separation of the armature, and F_1 the detaching force required on other occasions:

n.	F. kilog.	F_1 kilog.	Difference.
20	175	154	21
30	316	280	46
40	460	376	84
45	558	460	98
40	660	475	125
55	680	495	185

It may be remarked that F increases much more rapidly than F_1. However, F is of little consequence, since it disappears with the first separation, while F_1 is a permanent force expressive of the real power of the magnet. Taking a magnet of 45 laminæ, it will be found that its weight is about 46 kilog., while the above table shows its lifting power to be 460 kilog., that is, 10 times its weight. Magnets have been made in which this multiple reached the figure 20.

We have already said that the electrical exhibits belonged mostly to voltaic and magneto-electricity. There were few instruments relating to the earlier branch, the parent stem; and the most remarkable of these were the machines of Holtz and Winter, with which every student is familiar, and the battery of Dr. Jedlik, Professor of Physics in the University of Pesth. This is a statical battery, which presents several novel and interesting features. It is identical in principle with the Leyden battery, and differs from it only in a few peculiarities of construction. The problem which occupied the attention of Professor Jedlik seems to have been the production of a powerful statical apparatus, and this he has realised, adding special appliances for tension and quantity. The Leyden jar is replaced by a large glass cylinder, within which is placed a

number of smaller cylinders, which we might not inappropriately call Leyden tubes. Fig. 13, Pl. 242, is a section of the cylinder. It is 64 centimeters in length and 8 in diameter. Fig. 14 shows the construction of one of the tubes; the darkened portion represents the armatures, the length of which is two-thirds of that of the tube. Iron filings are substituted for the ordinary tin-foil. A, *d*, (fig. 14) is a wire leading from the inner coating and projecting a little beyond the extremity of the tube. The whole is 63 centimetres long; the external diameter is from 10 to 12 millimetres. The knobs, represented in fig. 13, are in electrical communication with the coatings, so that by connecting A and B, the cylindrical battery A B may be discharged.

There were two of these batteries in the Exhibition. In the first, the cylinders are parallel to one another. In their normal position they are horizontal, but are susceptible of a movement of rotation on their insulating supports. This mobility is necessary to dispose the battery for tensional effects. Here Professor Jedlik seems to have borrowed an idea from the galvanic battery. He charges his cylinders in such a manner that the balls are alternately electro-positive and electro-negative. This is effected by a contrivance called a distributor, shown in fig. 16. It rest on the table or stand of the apparatus, and is movable in a vertical plane. The balls marked 1, 3, 5, and 7, which exactly underlie the corresponding ones of the cylinders, are all connected by means of a thin copper wire, as are also those numbered 2, 4, 6, and 8. When the battery is to be charged the balls 1 and 4 are put in communication respectively with the positive and negative conductors of a Holtz, a Winter, or any other frictional or inductive machine, suitable for utilising the two electricities. The distributor is then raised by a simple piece of mechanism, so that its balls are brought into contact with the larger ones of the cylinders, which thus become positively or negatively electrified. If the balls be now connected together, according to their electrical state, quantity effects will be obtained, and tensional if the positive and negative be alternately connected, as shown in fig. 17.

The striking distance depends upon the number of cylinders composing the battery. In the apparatus which was shown in the Exhibition this distance is from 12 in. to 13 in.

The second battery differs from the one which we have just briefly described only in the position of its cylinders, which are upright. B in fig. 18 is an insulating support; A the glass cylinder containing the Leyden tubes. The balls C are in connexion with the positive coating, and those marked D with the negative by means of a bent tube, which descends to the lower extremity of A, and terminates in a metallic disc. To charge this battery, the positive balls, and also the negative, are brought into communication with a distributor similar to that above described. A partial discharge may be obtained by connecting any of the negative balls with the corresponding C positive. The whole is discharged by connecting the D of each cylinder with the C of the adjoining one, if tension be required, the first D assuming the dotted position C, G. By this arrangement H and I become the poles of the battery between which the discharge takes place.

The drawing in fig. 18 shows only one half of this battery. The two parts, which are perfectly similar, may be joined so as to form one battery, whose striking distance will be nearly twice as great as that of the four conjoined cylinders.

We have yet to notice another statical apparatus, which, though of recent invention, is nevertheless pretty well known. It was exhibited by Dr. Geissler, of Bonn, whose name is inseparably associated with some of the most beautiful experiments that can be performed by the agency of electricity. It is a vacuum tube that may be lighted without either induction coil or frictional machine. It consists of a tube an inch or so in diameter filled with air as dry as can be obtained, and hermetically sealed after the introduction of a smaller exhausted tube. If this outward tube be rubbed with a piece of flannel, or any of the furs generally used in exciting the electrophorous, the inner tube will be illumined with flashes of mellow light. The light is faint at first, but gradually becomes brighter and softer. It is momentary in duration; but if the tube be rapidly frictioned, its persistence on the retina will

render it continuous. If the operator have at his disposal a piece of vulcanite, previously excited, he may, after educing signs of electrical excitement within the tube, entirely dispense with the use of his flannel or fur. This will be found to minister very much to personal ease and comfort. He may continue the experiment, and with enhanced effect, by moving the sheet of vulcanite rapidly up and down at a very slight distance from the tube.

We need scarcely add, what must be apparent, that this beautiful phenomenon is an effect of induction. Similar tubes may be had from Mr. A. Apps, 433, Strand.

Dr. Geissler also exhibited two very small tubes, which are of special interest to the theoretical inquirer. They are about 3 in. long and ⅓ in. in diameter. They are carefully exhausted, the vacuum being, as the expression runs, as nearly perfect as possible. In one, the platinum electrodes are placed one above the other, and are either parallel or inclined at any angle; in the other, they are end to end, the distance being only a fraction of a millimetre. This second tube is also provided externally with two copper or platinum wires, fastened to the electrodes, and susceptible of being placed at any distance apart. When the electrodes of the first tube are connected with a battery, it would appear that the thin portions within the tube have a tendency to approach each other. We give this on the authority of Dr. Geissler himself, as we had not the leisure to make the experiment for ourselves.

When the second tube is connected with a coil, the induction spark leaps between the two exterior wires, though the distance between them may be 20 or 30 times greater than that between the terminals within the tube. This experiment is confirmatory of the theory which maintains the necessity of a ponderable medium for the propagation of electrical effects. As will be remembered, this is nothing more than the experiment of Hittorf, which Dr. Geissler's little tube is intended to popularise.

The magneto-electric machines exhibited at Vienna were by the Alliance and Gramme Companies, Paris, and by Siemens and Halske, Berlin. The last two were placed in the Machinery Hall, where, at appointed times, they were set in motion; the former was fitted up in an elegant monolith, constructed immediately opposite the western entrance of the Exhibition by Mr. Alexander Paul, the inventor of the "artificial granite."

While skilful electricians have been devising new magneto apparatus, or introducing important changes in existing ones, the Alliance machine has remained exactly what it was some 20 years ago, that is, when Van Malderen modified the magneto-electric apparatus of Professor Nollet—for it is well known that the Alliance machine is only an improved form of the beautiful invention of the Belgian savant.

The machine which was shown at Vienna is 4 ft. 6 in. in height, 3 ft. 6 in. in length, and 4 ft 3 in. in depth. It contains 64 bobbins fixed upon the circumference of four bronze wheels carried upon the same horizontal axis. These rotate before the poles of permanent magnets at a speed of about 450 revolutions per minute. The driving power necessary to attain this speed is three horse-power. A commutator is provided, so that when desired a current uniformly in the same direction may be obtained. As this appendage gives rise to occasional inconveniences, especially when maximum velocity is required, it must, to a certain extent, be considered a drawback or an imperfection; its removal would, therefore, be an improvement. This is effected in the Gramme machine, which we shall presently notice.

The Alliance apparatus has met with great success in France. This might have been expected, as it has the merit of having first afforded a solution to the important problem of the production of electricity on a large scale. Besides, for many years it was alone in the field, without any competitor to dispute with it the prize of success. The results it has given have in general been satisfactory. At its regular speed of 400 revolutions per minute, it generates a current sufficient to raise to a red heat, and even to fuse a piece of iron wire ·395 in. in diameter, and 4 ft. 6 in. long. The intensity of the light is equal to that of 250 Carcel burners. A beautiful bright beam was thrown almost every evening from the gallery of the above-mentioned monolith on various parts of the Exhibition buildings and the Prater. The optical

apparatus used was constructed by MM. Sautter, Lemonnier and Co., Paris—a description of which we have given above. Owing to the constancy and intensity of the light emitted by this machine, it has been adopted for all the electric lights on the coast of France. A recent report of the Directeur-Général of Lighthouses, speaks very favourably of the results it has achieved. It is particularly noticeable that the item for repairs is almost nil. Nor is this the only point of economy, for the daily expense required to maintain the electric light is shown to be one-fourth less than that of an oil light of the first order, while there is this great additional advantage that the intensities compare as five to one. It further appears that the cost of the carbon points does not average more than 2½*d.* per hour.

The machine has also been extensively used in the works of MM. Christofle and Co., Paris, where it generally deposited 320 grammes of copper, and 960 grammes of silver per hour. In the metallurgical department, however, it does not seem as efficient as the Gramme machine. This will be shown further on.

The cost of this machine is about 320*l.*, that of the electric light regulator 28*l.*, and the optical apparatus 120*l.*

The Gramme machine is a recent invention, having been patented in 1869, and first submitted to the Académie des Sciences in June, 1871. Its *ensemble* will be understood from the front view shown in fig. 19. The uprights are cylinders of soft iron coiled round with insulated copper wire. There are six of these, figs. 20, 21. They are 3 ft. $7\frac{6}{16}$ in. high, and $3\frac{5}{16}$ in. in diameter, and are connected at the upper end by a square plate of cast iron, and at the lower by a socketed base-plate $31\frac{1}{2}$ in. by $31\frac{1}{2}$ in. When the machine is in action these cylinders become electro-magnets, and thus form an intense magnetic magazine. The broad circular disc, fig. 19, is one of the armatures rotating between the poles of one of these electro-magnets. The poles are made to extend over one-third of its circumference by means of soft-iron projections. Two metallic brushes,—consisting of silvered copper wires held together by adjusting screws—shown also in fig. 19, are in contact with the arbor; they collect the current as it is generated, and transmit it to two large nuts, which serve as the terminals of the machine. One of the armatures excites the electro-magnets; the other two are connected together, and produce the current to be used externally. The armature consists of a ring of soft iron, round which covered copper wire is wound by lengths of about 10 yards. The contiguous ends of two of these lengths, represented in fig. 19 by two radial lines, are joined at the circumference of the ring to strips of copper, which connect them with conductors of the same material, placed longitudinally on the spindle. These conductors are insulated from one another by layers of silk, and it is from them that the brushes collect the current.

When the coils are set in motion, very weak currents are developed by the remanent magnetism of the soft-iron cylinders. These currents flow in opposite directions from the consequent magnetic poles of the ring, and are collected at the neutral points which correspond to the intersections of the horizontal and vertical diameters of the annular coil. As the metallic brush rubs against several of the axial conductors simultaneously, there will be no interruption in the induced current. Several experiments have been made with delicate galvanoscopes, and the results obtained confirm the theoretical conclusion of the continuity of the currents. These features of the apparatus dispense entirely with the use of a commutator, which is generally an inconvenient appendage, especially in machines of high tension. It is the current from the armature near the driving-wheel that is transmitted round the soft-iron cylinders. Each new increment induces a stronger current in the bobbins, which in turn increases the intensity of the electro-magnets; and by this mutual action, the magnetic capacity of the cylindrical cores is soon attained, when a very powerful battery is built up.

The coils are driven at a normal rate varying from 300 to 350 revolutions per minute. A three horse-power engine is sufficient to maintain this speed of rotation in the machine exhibited.

The current developed is equal to that of a Bunsen battery of 525 cells, arranged in five rows. The tension is therefore that of 105 cells, and the

quantity that of five. The wire in the armatures is No. 12, and weighs 165 lbs.; that on the electro-magnet is No. 11, and weighs 550 lbs. The height of the machine is 4 ft. $3\frac{1}{16}$ in., and its weight one ton.

Another valuable feature in this new machine, besides the continuity of its currents, is the facility it affords for increasing the number of revolving armatures without occasioning any great inconvenience. The advantage derivable from this is that several distinct currents may be obtained from the same machine and applied to various purposes.

There is nothing very delicate in the construction of this new magneto-electric machine, no element susceptible of easily presenting an opposing electro-motive force; and in case of a derangement, neither extra mechanical skill nor uncommon ability in electrical matters would be required to repair it. This machine will be found to replace with great advantage the ordinary powerful batteries used in researches or experiments in electro-dynamics, electro-magnetism, or electro-chemistry; but its especial use is not for the laboratory of the savant, but for lighthouses and metallurgical establishments. To answer each of these purposes, a particular arrangement *is necessary*. In the one case, as tensional effects are chiefly required, the electro-magnets must be wound with comparatively thin copper wire; in the other case, copper strips or ribbons are adopted, as they are best fitted to give quantity effects. This is the differentiating feature between the two sorts of machines.

The electro-typing machine exhibited at Vienna is a little smaller in size than the light apparatus just described and has only four instead of six electro-magnets. It is shown in fig. 22. B, B, are the electro-magnets; A, A, a cast-iron plate uniting them at the top. The wire is so coiled that poles of the same name are vertically opposite each other. H is one of the armatures, fixed on the same axle as the driving wheel E. C is the part of the arbor on which the useful current is collected, by means of the silvered copper brushes D, D. A similar arrangement is placed near E, which transmits a current round the soft-iron cylinders, thus converting them into a strong magnetic magazine. The metallic brushes insure good soft contact, and when duly attended to prevent the occurrence of sparks from the extra current. As in the light machine, there are four of these brushes; two to collect the current necessary to make the electro-magnets, and the other two to collect the useful currents.

The wire coiled round the fixed electro-magnets weighs 270 lbs.; that around the two circular armatures 80 lbs; the whole machine 920 lbs. The normal speed is about 300 revolutions per minute, and this may be attained by a one-horse power. The tension of the current is equal to that of two Bunsen elements, whilst the quantity equals that of 32. This machine has been tried in the extensive works of MM. Christofle and Co., Paris; the results obtained have been compared with those of Wilde's excellent apparatus. As this point may be of considerable interest, we shall give the details of these experiments, as recorded in the Comptes Rendus Hebdomadaires des Séances de l'Academié des Sciences" for December 2, 1872.

GRAMME MACHINE.

Total Deposit.	Time.	Surface of Anode.	Deposit per Hour.	Speed.
oz.	h. min.	sq. ft.	oz.	rev.
209·05	7 50	57·62	26·81	300
206·67	7 50	57·62	26·49	
209·02	7 50	57·62	26·81	
214·09	7 50	57·62	27·44	300
69·30	2 50	38·41	24·74	
69·47	2 45	38·41	25·27	
70·49	2 45	38·41	25·62	300
54·50	2 35	28·81	21·10	
55·75	2 45	28·81	20·33	
53·90	2 40	28·81	20·23	

WILDE'S MACHINE.

Total Deposit.	Time.	Surface of Anode.	Deposit per Hour.	Speed.
oz.	h. min.	sq. ft.	oz.	rev.
51·83	3 30	28·80	14·80	2400
40·04	2 30	28·80	16·00	2400
51·83	3 5	28·80	16·80	2400
59·11	3 35	28·80	16·52	2400

By inspecting these tables, it will be seen that the advantage is much in favour of the Gramme. Moreover, the rapidity of rotation in the second case gives rise to many inconveniences which do not occur in the first. The machine with which these comparative trials were made, has been in operation for more than two years, and has not required any material reparation.

Messrs. Siemens and Halske, of Berlin, exhibited three magneto-electric machines, two of which are identical in construction. One of these is shown in fig. 23. It is constructed on the principle of mutual accumulation. A small cylindrical armature is made to rotate rapidly between the extremities of two plates of soft iron placed vertically, which are joined together at the top by a third plate. When the smaller armature is first set in motion, the infinitesimal amount of residual magnetism in the iron suffices to develop a feeble current in the copper wire wound longitudinally on the armature. This is transmitted round the soft-iron plates. By this increment a stronger current is now induced and transmitted in like manner. The soft-iron plates of both parts of the apparatus are thus converted into powerful electro-magnets, between the poles of which rotates the armature, producing the current to be used externally.

A one-and-a-half or a two horse-power engine drives both armatures with sufficient rapidity. The usual speed of the smaller armature is about 1,600 revolutions per minute, and that of the larger 800 revolutions. At this rate, the machine produces a light equal to 2,500 normal candles. On several evenings, this bright beam was thrown with very pleasing effect upon the imperial crown that decorates the culminating point of the Rotunda.

The great rapidity of rotation required, besides the mechanical deterioration of several parts of the apparatus, causes a considerable generation of heat in the armatures. The injurious effects to which this may give rise are in great part obviated by a stream of water, which maintains them at an ordinary temperature. The water proceeds from a small vessel placed exactly over the armature, or from a system of pipes, as shown in fig. 23.

These two machines are mounted on carriages for convenience of transportation, and suitable portable engines are provided to work them.

The second machine involves the more recent advances of magneto-electricity. Indeed, it was only late in June that the apparatus was completed and sent to the Exhibition. In its *ensemble* it resembles ordinary magneto machines; the novelty lies in the construction of the armature, which bears so close an analogy to that of the Gramme as to lead to the conclusion that the one may have been suggested by the other. It has been experimentally shown that the rotation of the soft-iron ring is attended by a diminution in the strength of the current induced in the overlying helix. An experiment establishing this principle was made by M. Gaugain, and recorded in a paper submitted to the Académie des Sciences, in which that able physicist investigates the development of the currents in the Gramme machine. Accordingly, in the apparatus exhibited at Vienna, the core of the armature is fixed, and the helix alone is made to rotate. Several further modifications are also introduced. The ring of the Gramme is replaced by a solid cylindrical core, around which the wire is coiled longitudinally, as in the ordinary Siemens armature. By this arrangement, a very energetic current is produced, with but a compara-

tively small expenditure of power, since the mass of the armature is stationary. The temperature of the wire coiled round the electro-magnets is also considerably raised, but this is partly attributable to the circumstances in which the machine was constructed which did not allow all the time necessary to duly calculate and dispose the various parts. With proper attention to the thickness of the wires, and the regulation of the driving power, much of this heat may be made to disappear. This new system is called that of Hefner-Alteneck.

Among the smaller magneto-electric apparatus, which attracted our notice, we should mention those exhibited in the French department by M. A. Gaiffe, Paris, and which are intended for medical purposes.

The experience of practitioners generally points to magneto-electricity as preferable to galvanism in medical treatment, for the convenience attending its development, the various orders of currents that may be obtained, and the ease with which their strength may be graduated. The number of instruments of this kind that has been made is certainly legion. Though differing from one another in form, they are all analogous in principle, and that principle is the very rationale of magneto-electricity.

Clarke's apparatus was, at an early stage, applied to therapeutics. Subsequently Dr. Duchenne introduced an important modification. He divested Clarke's circular armature of its insulated copper wire, winding it on the extremities of the arms of the magnet only. When the bare soft-iron armature rotates in a magnetic field, it disturbs the state of the opposite magnet, and the change in the magnetic distribution thus effected induces in the wire currents which may be utilised in the ordinary way. Dr. Duchenne obtains currents of the second order by coiling over the first helix a number of convolutions of a second wire.

In the apparatus of M. Gaiffe, the systems of Clarke and Duchenne are combined. The priority of the idea belongs to that fertile electrician, M. Nollet, of Brussels; but M. Gaiffe has the merit of having reduced it to practice in the most satisfactory manner. His helices are placed both on his armature and on the ends of his magnet. This combination gives rise to currents of greater strength than those of the ordinary Clarke machine. It has been experimentally shown that with a magnet weighing 500 grammes, and carrying 6 kilogrammes, effects may be produced equal to those of a Clarke's apparatus, in which the magnet weighs 5 kilogrammes, and carries 20 kilogrammes. These results depend not only upon the system of coiling the wires, but also upon the dimensions of the armature, the thickness of the wire, and the number of turns—all of which have been practically determined by M. Gaiffe.

The current induced in the helix of the magnet is always in the same direction; but that developed in the coils of the armature is alternately positive and negative. If, then, the two pairs of bobbins be coupled together, the currents produced during the first half of the revolution, being in the same direction, will combine to produce an effective current of double strength; but in the second semi-revolution, the currents being opposite in direction, would neutralise each other. This difficulty was easily removed by the adoption of a commutator similar to that of Clarke, by which the currents of the rotating armature are reversed when required. A second commutator is also added; it suppresses currents of too feeble a tension, and produces the intermissions necessary for the development of the induced current. The strength is indicated by the usual needle and dial. Each division on the latter corresponds to a motion of the armature equal to the $\frac{1}{25}$th of a millimetre. This exactness is especially necessary when the armature is close to the magnet, as then the slightest movement of the former produces very great differences in the physiological effects.

Close to the dial are two studs, marked according to their polarity. These are, as it were, terminals of the apparatus, and are destined to receive the ends of the conducting wires. In the instruments intended to give secondary currents, another pair of studs, specially marked, denote the new poles.

This apparatus, which produces currents of considerable energy, has the additional advantage of being rather small in its dimensions. It may be

enclosed in a box 10 centimetres long and 17 wide. Several physicians of distinction have recommended this apparatus, as eminently adapted for medical purposes.

Among the recent applications of electrical science, an interesting and, as it may eventually prove, a useful exhibit, was an automatic whistle, constructed on the system of MM. Lartigue and Forest, by Digney Frères, Paris.

This apparatus possesses certain points in its favour; its dimensions are such as not to inconvenience the engineer, whilst its effects may tend to the prevention of those catastrophes, which, from time to time, send a thrill of horror through the community at large.

It is claimed that this instrument may be used with advantage on all occasions; but it is especially serviceable in times of fog, pelting snow, or driving rain, when optical signals are inefficient. It consists of a bronze whistle, which communicates with the boiler, and is enclosed in a metallic box fixed on any convenient part of the engine. The electrical arrangement is shown in fig. 24; A, B, is a horse-shoe magnet—Hughes' system; C is one of the coils of insulated wire wound on the soft-iron cylinders, inserted in the arms of the magnet; D, H, is a lever represented in the figure in its normal condition, that is, in contact with the poles of the magnet; M, N, is a spring whose elastic force is a little less than the attractive power of the magnet. If a current of determined direction be admitted through L, it will pass through the bobbins; the electro-magnet will be unmade, and the lever D, H, will yield to the pressure of the spring M, N. This depression of the lever affording free passage to the steam, the whistle sounds, and will continue to be heard until the engineer, pressing upon the outside button K, brings the lever within the immediate influence of the magnetic poles, and thus restores it to its former position. The completion of the electrical current will be easily understood. The wire L leads from an insulated metallic brush, so placed under the locomotive that the ends of the wires which compose it project a few centimetres beyond the lower parts of the engine. At the required distance from the signal-box, a fixed contact, fig. 25, is placed longitudinally in the middle of the road. This contact consists of a long piece of wood firmly secured to iron supports, and covered with a thick layer of an insulating material. The upper surface is covered with a sheet of copper, which, by means of a wire of any desired length, is connected with the positive pole of a battery. The negative pole communicates with a commutator, which puts it to earth when the road is blocked, and insulates it when the way is free. If we suppose the station to be blocked, then when the engine reaches the fixed contact, the metallic brush, in rubbing against the underlying sheet of copper, is virtually placed in connexion with the positive pole. The current passes through L, fig. 24, to the coils C, and thence to earth through the coil E, the engine itself, and the rails. It may be here remarked that the effect never fails whatever the speed of the locomotive may be. Experiments have been made always with the most satisfactory results with an engine running at a very high speed. To ascertain whether a layer of snow might not present a serious obstacle to the proper working of the apparatus, the sheet of copper was carefully covered over with gravel; but in the passage of the engine this was all swept away by the metallic brush, which at the same time established good contact. The solidity of the construction has also stood various tests. It might be thought from *à priori* considerations that the brushes are subject to considerable deterioration from wear and tear, but this does not appear to be the case, experience showing that, even in very unfavourable circumstances, this expenditure is trifling.

The fixed contact is represented in fig. 25; the section shows the electrical arrangements. This contact is generally placed lengthwise between the rails as stated above; but in countries in which snow storms are of frequent occurrence, other dispositions, which will easily suggest themselves, may be found necessary.

The length of the contact affords a striking illustration of the instantaneous character of electric currents. In the earlier trials made under the direction of M. Delbecq, engineer to the Chemin de Fer du Nord, this length

did not exceed 13 ft. Express trains would pass over this distance in one-fourth or one-fifth of a second—almost an inappreciable point of time—yet the continuance of the current during this brief interval never failed in its effects. But even this length may yet be diminished without diminishing the certainty of the results. It has lately been determined that 6 ft. 6 in., or half the original length, will suffice on all ordinary occasions.

Fig. 26, Pl. 243, is a transverse section, showing the passage of the brush of the fixed contact and the position of the latter.

This ingenious apparatus was adopted by the Chemin de Fer du Nord at the beginning of last year, after a series of experiments extending over a space of eight months. It has well answered its purpose; and we think that its introduction into this country might be found a valuable addition to our ordinary fog-signals.

We shall now advert to another apparatus called forth by the necessity of protecting railway stations by an efficient system of signals against the occurrence of accidents. It was exhibited by the Austrian North-Western Railway Company. This apparatus is called the magneto-electric station-signal, and consists of an optical signal-arm movable on a horizontal axis passing through its centre of gravity, and supported by a cast-iron column called the signal-post. Motion is imparted to the axle and arm by a crank-shaft and lever, worked by a special mechanism, which is placed in a cast-iron casing secured behind the arm. The amplitude of the movement of the arm is limited to 45 degrees, and by this oscillation its longitudinal axle is made to occupy alternately a horizontal and an oblique position. This movement is effected by a powerful magneto-current.

The upper half of the signal-arm is painted red, and the lower half white; while, to render it still more conspicuous and striking, it is perforated in vertical parallel strips.

The horizontal position signifies "stop," and the oblique "line open." During the night a red light is shown to an approaching train if the line be blocked, and a white to the station. For line free, a green light is shown in both directions. In order to facilitate the changing of the coloured lights, the signal arm is continued beyond its axle, and forms a projection similar in outline to a pair of spectacles. Behind these is placed a large lantern provided with a concave mirror, which throws a white light in the direction of the free line and the station. The projecting spectacles are provided with a red and a green glass. A similar arrangement is fitted up at the other extremity of the axle of the signal arm, and by this means either a red glass may be placed in front of the lantern, or a green glass may be placed simultaneously behind and in front of the mirror, by which combination the desired effects of light are produced. For the purpose of cleaning and trimming, the lantern may be lowered by a chain, which glides over two rollers fixed in the top of the column. The wheelwork is wound up by a contrivance attached to the pedestal. One winding will suffice for eighty signals, forty "stop" and forty "line free."

The movements of the arm are produced by strong magneto-electric currents sent from the station. As soon as the current passes, the electro-magnet E, fig. 27, is made. The armature *m* is attracted, and the fork G, which is fastened to the same axle as the lever of the armature, turns a little to the right, and the prism-shaped end of the long lever *h*, *h*, drops from *b* to *c*, the two prongs of G.

When the current is interrupted, the armature is withdrawn from the electro-magnet by the opposing spring *f*; the lever *m* and the fork G will then slightly move towards the left, and the prism-end resting on *c* falls from the latter into the intermediate space of the fork G.

By the depression of the lever *h*, the hook *g* moves towards the left, thus freeing the cam and the pinion I., and setting the working part of the apparatus into motion. The ratchet *g* now releases pinion IV., whence the crank-axle *x*, which is secured to the latter, begins to revolve. The rotating movement of this crank-axle is transferred by the coupling rod *z* and the lever *k* to the axle of the signal arm. The inclination given to *k* is equal to that of the signal arm, namely, 45 degrees; and as the double throw of the crank-axle *x*

equals the play of the lever *h*, it follows that half a revolution of the former corresponds to the full amplitude of the motion of the latter.

The parts are thrown out of gear by the double eccentric of pinion IV., which catches the cam of the lever *h*, and so raises the latter that the prism-end is above the tongue *b*, upon which it falls as soon as one of the eccentrics has passed under the cam *b*. In the meantime the ratchet *g* has been forced by the spring *s* into one of the indentations on pinion IV., by which means the cam of pinion I. comes into contact with the other end of the ratchet *g*, and thus stops the motion of the arm. Figs. 29 to 37 show the details of the apparatus.

The signals are worked from the telegraph office at the station, and consist of a magneto-electric apparatus developing strong currents. While the operator turns the handle of the magneto-machine, he depresses a key at the same time, and thus sends the current through *l*, fig. 28, round the electro-magnet of the column, whence it returns to the apparatus.

The battery shown in fig. 28 is used, ascertaining the proper action of every part of the system. For this purpose three alarm-bells are fitted up respectively at the first signalman's post, outside the station, and immediately outside the telegraph office. An optical apparatus is also established at the latter office, and is electrically connected with the bells by means of the so-called controlling wire *l''*. Matters are so disposed that if the station signals "stop," the battery circuit is closed, the bells ring, and the optical signal in the telegraph office shows a red disc upon a black ground. It may happen that, owing to some defect or impediment, the alarm bells do not ring; but it has been found that even a very weak current will invariably work the optical apparatus, and thus record in the office the actual position of the signal-arm.

We shall now proceed to give an account of the most interesting telegraphic exhibits.

The German Government conceived the happy idea of forming a collection of telegraph instruments, so as to enable the visitor to realise the astonishing progress made in the course of a few years in this branch of science. The collection had a national character, that is, it embraced only the contributions of German genius. This feature necessarily detracted from the completeness of the exhibits as a class—compelling the inquirer to supplement his information in other quarters—but at the same time it showed that German savans were soon in the field, and that they carried on their explorations with diligence and success. The earliest apparatus we noticed is that of Sömmering, 1808; and the latest that of Jaite, 1872. The intervening period is represented by a considerable number of transmitting and receiving instruments, relays, commutators, galvanometers, &c.

The most important, as also the most interesting, of these exhibits were the apparatus of Sömmering, of Gauss and Weber, and of Jaite—the first two as being the earliest contrivances towards rendering telegraphy practicable, and the last as embodying the most recent improvements. We say nothing of Baron Schilling's telegraph, as there were only a few designs showing the disposition of the needles, and the method of signalling.

Sömmering's apparatus is based upon the hap-hazard discovery of Nicholson and Carlisle, viz., the decomposition of water by the galvanic current. He strung 35 insulated wires into a cable, and led them from a metallic terminal at the transmitting station to as many gold points enclosed in small glass tubes filled with water. On the passage of the current, the letters or numbers, intended to be signalled, were recognised by the development of the respective gases, hydrogen taking precedence. This apparatus is still in good state of preservation.

Gauss and Weber applied Faraday's discovery; they were the first to transmit signals by means of magneto-electric currents. Their apparatus seems to have been constructed with a view to solidity, rather than to elegance of appearance. Two large bar magnets are maintained in a vertical position, with similar poles together; around these a wooden bobbin, provided with handles, and wound with a considerable number of turns of covered wire, is free to move in a vertical plane. The slightest motion of this coil suffices to generate currents which are transmitted in the usual way round a multiplier,

the signals being given by the deflections of the enclosed needle. As the approach of the coil to a pole, and its withdrawal therefrom, give rise to opposite currents, these are reversed, when necessary, by a commutator constructed on the principle of bringing two points alternately into electrical communication with two others. The magnet of the receiving instrument is 1·21 metres long, 0·075 wide, and 0·015 thick. It will be remembered that it was while engaged in perfecting this apparatus, as well as the whole system of Gauss and Weber, that Steinheil made his remarkable discoveries.

We have already said that one of the most recent additions to telegraphy is the apparatus of G. Jaite, Berlin. Early in 1868, the attention of Mr. Jaite seems to have been concentrated upon determining an efficient method of using Hughes' apparatus for the purposes of translation. In this important problem, he finally succeeded by supplying the armature of the electro-magnet with a flat insulated spring, and by adding two contacts which limited the oscillations of the spring. The difficulty, however, attending the maintenance of synchronism, and the exact transmission of currents, both as regards intervals of time, and duration of contact, soon induced him to abandon the old method, which requires two different translators, and to investigate the possibility of establishing correspondence between two distant stations by means of one translator, and some other auxiliary instrument if need be. The subsequent trials and researches led to the invention of the instruments shown in figs. 38, Pl. 243, and 39, Pl. 244, and which we shall now proceed to describe.

Fig. 38 is a general view of the telegraph instrument. It consists of the usual train of clockwork, two polarised magnets, two perforators, and a double automatic key.

The clockwork is enclosed within a metallic case, and is driven by a weight of 100 lbs. It is regularised by the simple contrivance shown in fig. 40, when the messages are sent by means of the double hand-key; but it is found necessary to replace this centrifugal by a Hughes' regulator, when the apparatus is used for automatic transmission.

The polarised electro-magnets are modelled after those of Hughes' system. They differ from the latter in having the soft-iron projections inserted, not at the ends, but at the magnetic poles of the permanent magnets. These consist of three bars of steel of equal magnetic force, and bent in the form of a horse-shoe.

The paper is unwound from a drum placed under the table, and is guided by two rollers turning in opposite directions. By means of the levers shown in fig. 40, the operator may interrupt the progressive movement of the band at any moment. The lever-arm terminating in a circular disc is used for increasing or diminishing the pressure of the guiding cylinders.

The perforating mechanism corresponds to the capstan-headed screws in fig. 38; it is shown in detail in fig. 42. The cam X^2 is mounted on the axle *b*, fig. 38, and is driven by the train in the direction indicated by the arrow, fig. 42. At every revolution of this axle, the inclined lever V^2 is raised; the screw *i* strikes a smart blow upon the frame *f, f*, which is suddenly depressed, and with it the accompanying perforator. The elasticity of the spring now comes into play, and restores *f, f*, to its normal position. It will be seen, by figs. 38 and 43, that there are two perforators separated from each other by a small interval, and worked by two distinct levers. The object attained by this double mechanism is to punch a hole either in the upper or lower half of the paper band, and thus to allow the formation of a complete code of signals.

The hand-key represented in the front part of fig. 38 consists of two simple Morse keys nicely adjusted. The buttons are placed very near each other, so as to facilitate the operation of transmission.

The double automatic key consists of various pieces revolving on the axles *a* and *b*, fig. 38, and are shown on an enlarged scale in fig. 44. The outer circumferences are divided into three segments marked R_1, R_2, B_1, B_2, and E_1, E_2. The sections B_1, B_2, are in permanent connexion with the battery, whilst E_1, E_2, lead to the earth-plates. The inner portions L_1, L_2, are metallic rings, which are in electrical communication with the line-wire. The contact segments R_1, R_2, B_1, B_2, E_1, E_2, are insulated from one another by ebonite

plates P_1, P_2. The cross pieces S_1, S_2, are flat springs, carefully insulated, and are mainly instrumental in effecting the translation on the message. When the apparatus is at rest, the springs S_1, S_2, communicate at one end with L_1, L_2; and at the other with R_1 and R_2. B_1 and B_2 are joined with the contact pieces of the earth and battery commutator, so that they may be either connected with the different batteries, or be put to earth as the case may require. When two translating batteries are used—as is generally done —the metal ring L_1 communicates with the line; and the springs S_1 connects —when the apparatus is at rest—L_1 and R_1. This last segment is joined by a wire with L_2, which communicates with R_2, by the spring S_2. During the period of translation, the automatic commutator is connected with R_2.

When a current is sent around the polarised magnets one of these is instantly unmade, whilst the magnetic intensity of the other is greatly increased. This will be obvious if we consider that the wire is wound in the same direction round the soft-iron cylinders. One of the armatures will be released, whilst the other will be attracted with greater force. The former will undergo, by the action of a horizontal spring, a slight vertical displacement, which will raise one arm of a long lever, fig. 38, and depress the other. This end, which fulfils the office of a detent, couples the two shafts *a*, fig. 38, and X_2, fig. 42, and makes them turn together. In this way, the alternate movement of V_2 is obtained, and thereby the punching of the paper band. In the meantime, opposite effects are produced at the other electro-magnet. The armature is drawn down, and the axle carrying the cam wheel, which lifts the inclined lever, is not coupled with the main shaft, and it therefore remains quiescent.

We have already said that the translating springs S_1, S_2, are connected by sliding contact with the line wire, and as they rotate with the shafts *a* and *b* (fig. 38), it is evident that during the same revolution the line is separated from the coils of the automatic commutator, charged in passing over section B_1, fig. 44, discharged to earth at E_1, and finally connected again with the commutator at R_1; S_2 undergoes the same series of changes. The perforation of the paper takes places when the shafts *a* and *b* (fig. 38) have described an arc of 270 deg., and the springs S_1, S_2, are beginning to slide over the contacts E_1, E_2. The hole in the band records, therefore, not only the displacement of the armature, but also the charging and discharging of the line by means of the double automatic key. As the surfaces of R_1, B_1, E_1, and R_2, B_2, E_2, are respectively in the same vertical planes, we may infer that the rotating springs will invariably fulfil their twofold office of charging and discharging the line.

The second part of the problem of translation is solved by the automatic commutator shown in fig. 39. It consists of a train of clockwork, driven by a weight varying from 20 lbs. to 35 lbs., three revolving commutators, a polarised magnet, a translator, and a bell. One of the commutators—that connected with the lines—is represented at *a*. A second, connected with the batteries, rotates at the other end of the axle a_1, while the third, also connected with the batteries, revolves on the axle a_2. The wheel W_1 is not fixed to its shaft a_3, but only secured by two brass friction plates. The axle a_4 carries a pinion with 20 teeth, which gear into wheels—having 80 teeth on their circumferences—fitted on the axles a_1 a_2, and thus drive the commutating portion of the apparatus. When the pinion axle is maintained at rest by the detent *d* the whole system is inactive; but when, by the passage of a current, the Hughes' magnet is unmade, the armature is detached from the core, the screw end of the lever is raised, and the shaft turns round once. The flat springs of the commutators revolve with their axles; however, they cannot pass over more than an arc of 90 deg. By this movement it will be easily seen that the line L_1, having been in connexion with the coils of the telegraph, shall afterwards communicate with those of the commutator c_2, and that line L_2 shall pass from connexion with the commutator to connexion with the telegraph coils. As the translating batteries correspond to L_1 and L_2, it follows that if line L_1 is connected with the telegraph coils the corresponding batteries are in communication with the double hand-key; and if line L_1 communicate with the coils of the automatic commutator the corresponding batteries communicate with the double automatic key.

When the armature of the electro-magnet is detached, the translating spring *p* touches the lower contact-anvil, and in so doing closes the battery-circuit, signalling at the same time, by translation, the interruption of the receiving terminal station back to the transmitting terminal station, and that before the connexions are commutated by the flat springs. As the axle a_1, a_2, are driven by the same pinion, every commutation is announced at the translating station by the ringing of the bell. If the operator choose to connect the two line-wires, and establish several other minor contacts, he may indulge in any relaxation without the least anxiety; for the first electric impulse sent by either station is sure to ring his bell. It would be superfluous to dwell on the advantages of such a self-acting commutator.

To render all this clearer, let us suppose London to be the transmitting, Liverpool the translating, and Glasgow the receiving stations. Should it be desired to reverse the order, all that the telegraphist at Glasgow has to do is to press down his left key. This will suffice to change the electrical connexions at Liverpool, so that London becomes the receiving and Glasgow the sending station. In a similar manner, a second reversal may be effected at London by merely depressing the left-hand button of the key. We may add that the transmitting station is always in communication with the coils of the telegraphic apparatus and the receiving station with those of the automatic commutator, established at the translating station. Let us again suppose London to be corresponding with Odessa *viâ* Brussels, Berlin, Warsaw, and Moscow. A current from London may detach one of the armatures of the instrument at Brussels, but it does not influence the translation at Brussels, and therefore has no effect on the apparatus at Berlin. The other intermediate stations are equally unaffected. The operator at London may handle his double-key as quickly as he wishes, the translating axles at Brussels will revolve with the same speed. Providing the London operator make good contact, the line will always be charged and discharged at Brussel as explained above. We thus see that this apparatus permits us to establish a considerable number of translating stations without occasioning any delay in the transmission of the messages.

We are told that upwards of 17,000 despatches were sent from the Exchange at Berlin to the Hamburg Exchange, under the supervision of Mr. Jaite himself, and with the most satisfactory results.

This telegraphic apparatus is made by W. Gurlt, Berlin. There was a model exhibited in the German Government collection of telegraph instruments, and two others, together with an automatic commutator, also by Mr. Gurlt.

In the English section Messrs. Siemens Brothers exhibited a variety of improved Morse's and Hughes', and several of their own alphabetical and finger-key dial instruments. We should also mention a reflecting galvanometer, which attracted our attention less by the novelty of its construction than by its great delicacy. The mirror carrying the small magnet is best described by saying that it bears a close resemblance to the figure obtained by cutting an ordinary thimble into two equal parts by a vertical plane through its principal axis. On either side of the mirror are placed two distinct coils of wire. One of these may be taken out and removed 8 in. or 10 in., and even further, from the instrument, when upon the passage of a current it will be found to act inductively upon the small coil in proximity to the magnet, and to produce a deviation of 10 degrees or 15 degrees. This galvanometer affords a very striking instance of the inductive action of currents.

The finger-key dial instrument is an ingenious and very convenient apparatus for transmission. It is worked by magneto-electric currents. Its principle of action will be understood from fig. 45. H and H_1 are pivots on which the armature or keeper E is mounted horizontally; *g*, *g*, *g*, are a series of permanent magnets. Two handles *h*, *h*, are fastened to the spindle *a*, *a*, carrying a toothed wheel *l*, *l*, which gears into the pinion *t* of the cylindrical armature. Two revolutions of this wheel cause the pinion of the armature to revolve thirteen times, the teeth of the former being to those of the latter in in the ratio of 13 to 2. Situated exactly under the centre of the dial is a small cam, which engages with another cam fixed to the end of a vertical

shaft. The lower extremity of this shaft carries a disc with thirteen pins or studs.

The handles *h*, *h*, which set the armature in motion, are screwed with opposite threads. By this arrangement the operator is compelled to turn the handles in the right way, as by doing the reverse he unscrews these handles and leaves the whole instrument in electrical inaction. The diameters of the various wheels are so disposed that two revolutions of the handle *h* will revolve the armature E thirteen times, and the vertical shaft with its disc of thirteen pins only once. Now, as each turn of the armature produces two currents, the one positive and the other negative, in the wire coiled round the soft-iron core, it will be obvious that twenty-six currents are developed, and that they are alternately positive and negative. The dial is divided into twenty-six parts, twenty-five for the letters of the alphabet (I and J being considered as one), and one blank, which serves an important purpose in signalling.

The form given to the armature is not without its advantages. By the extent of surface it offers to magnetic induction, it gives rise to powerful currents, and by its small diameter and cylindrical shape it prevents the accumulation of too great a momentum.

Fig. 46 is a plan of under side. I is the peg disc, *p* a spindle, M an arm, concentric with *p*. A second arm b^1 is fixed with a spring on the axle that carries M. The end of this arm oscillates between two contacts, *c* and c^1. When M begins to revolve as indicated by the arrow, b^1 moves from *c* towards c^1, on account of the friction about the common centre, distending at the same time the spiral spring *s*. When the tail of the spring-catch *b* meets the depressed finger-key, it will free from the pin retained before and assume the position shown by the dotted lines, thus allowing the disc wheel I to rotate freely. The friction between the centre of M and the arm b^1 having ceased, the spring *s* will now act alone and restore b^1 to its former position in contact with *c*.

At the extremity of the arm M a catch *b* is fixed, which by a spiral spring is always drawn towards the centre, so as to catch one or other of the thirteen pins of the disc wheel I. If a finger-key *f* is depressed, and the tail of the spring-catch *b* strikes against it, the catch opens and releases the stud of the wheel I, the catch *b* with the arm M will be retained, while the disc I continues to revolve. By the depression of a second finger-key, the one first depressed will be raised again, the spring-catch *b* will be released, and it will catch the nearest pin to the disc wheel I, and move on with the arm M, until stopped by the key last pressed down. As before stated, an entire revolution of I corresponds to thirteen revolutions of the armature, or to twenty-six currents alternately positive and negative; and if we call c^1 the sending contact, as many currents will pass from c^1 into the line. When the spring-catch *b* and the arm M are detained by a depressed key, it suffices, in order to set this arm in motion, to press down another finger-key; then the number of currents passing from the contact c^1 into the line will be proportional to the arc passed over by M in reaching the newly-depressed key. These currents act upon the indicator of the receiving and transmitting instruments in such a manner as to move the pointers over arcs likewise proportional to the number of currents entering the line. As the pointer of the receiving station passes over an arc equal to that between the released and depressed finger-key, it follows that the pointer will indicate the same letter at the receiving station that was pressed down at the sending station. In this manner the various letters of the message are transmitted.

The receiving portion of the instrument is shown in fig. 47. A permanent magnet of bar steel carries on its north pole an electro-magnet m, m^1, the cores of which form continuations of the north pole, and receive from it north polarity. A small tongue of soft iron T is inserted in the south pole, and plays between the extremities *n* and *s* of the electro-magnet. These extremities are influenced by the adjacent north pole, and thus assume north polarity. They exert an equal attractive force on T, when the latter is midway between them; but when a current, traversing the coils *m* and m^1, imparts south magnetism to *s*, and addsnorth magnetism to *n*, the tongue will be repelled from the *s*, and at the same time attracted to *n*. If a current of opposite direction

be sent from the transmitter, the effects will be merely reversed, as must be apparent since the polarities of the extremities are thereby reversed.

The soft-iron tongue T thus moves alternately from one pole of the electro-magnet to the other, in accordance with the currents sent from the transmitter. To T is attached an arm A, which serves as one of the bearings of the axle of the escapement wheel. Two stops, p and p^1, determine the swing of this wheel, and are so adjusted that while passing from one to the other the wheel shall be turned by the spring hook h, half the length of a tooth in the direction indicated by the arrow, and during this time the hook h slides over to the next indentation, and is thus ready to draw the wheel an equal distance in the same direction when the latter returns from p^1 to p; h_2 and h_3 do not press down the spring hooks; they are intended merely to prevent the excessive vibration that might be caused by rapid transmission.

The two capstan-headed screws, q and q^1, are arranged to control the oscillations of the tongue T; n and s are the adjustable poles of the electro-magnet. They should be made exactly to balance polarities, that is, so disposed that the tongue may remain in any position assigned to it. K is a knob by means of which the pointer may be adjusted.

This instrument is substantially made; it is portable, and occupies but very little space. No technical skill is required in transmitting or receiving; and a little practice will enable the operator readily to send 100 words per minute.

These qualifications render the instrument especially serviceable on railway lines, in factories, docks, private offices, public institutions, and for military purposes.

We did not find in the French section such a multiplicity of telegraph instruments as in several other departments of the Exhibition; but, we may say, that this lack in quantity was compensated by quality and originality. The two exhibits of M. Meyer, of the administration of telegraph lines, Paris, deserve special attention. The one is an autographic, and the other a multiplex apparatus.

Fig. 48 is a front view of the former, showing the general disposition of the various parts. A and B are two cylinders driven by the same train of wheelwork, which is set in motion by the weight W. A is the transmitting cylinder, that is, the one around which the strip, containing the message to be sent, is wound. Close to this cylinder, which is insulated from the other parts of the apparatus, is placed an endless screw H, fig. 49, which is also driven by the same train. This screw also carries a slide I, susceptible of being moved in a line parallel to the axis of A. From the slide projects a metallic brush D, and a style C. These are insulated from each other, and constantly rub against the metallic surface of the telegram paper. At each revolution of the cylinder A, the slide is displaced the one-fourth of a millimetre, so that every point of the surface of A comes successively into contact with the style C. This style is in permanent electrical communication with the earth. At the transmitting station, the positive pole of the line battery is connected not only with the line, but also with brush D. By inspecting fig. 49, it will appear that the battery circuit is constantly closed, and that the distribution of the current depends upon the position of the style C. When the tracing point of this style touches the metallised surface of the paper, the battery current takes the course of least resistance, passing through the brush D over the paper to C, and thence to earth. In this case only a derived current, which is practically negligeable, passes through the line. But when the style is on any letter of the message, then, as this letter is written with a non-conducting ink, the short circuit is open and the battery current is sent in its entirety through the line wire.

We have here described the transmitting part; but each apparatus is also provided with a receiving instrument, so that a facsimile of the telegram is produced at each station. The receiving cylinder B, fig. 48, is shown on a larger scale in fig. 50. A triangular metallic thread O, B, is wound around it, so that the helicoidal figure thus formed shall describe only one convolution around the cylinder. This thread constantly rubs against an ink roller J, and makes on the receiving paper a series of short lines, which gradually

become complete, and thus form the letters of the message. All the words in the same line are traced simultaneously. This may be seen by referring to fig. 51 which is a facsimile of a despatch.

If we suppose the strip of paper upon which the despatch is to be autographed to remain in contact with the helix of cylinder B, it will be easily seen that this metallic thread will trace a straight line transversely on the paper; on the completion of this line, a second one will be traced parallel to it, and so on. From this, the necessity of breaking contact, or in other words, of withdrawing the paper, will be apparent. The interruption is obtained in the following manner:—The metallic frame G (fig. 50), which supports the receiving paper, is so pivoted as to admit of a very slight depression around its axis of motion. Under the frame is fixed an electro-magnet E, whose core projects a little in both directions beyond the edges of the bobbin, and thus comes within the influence of the poles of a permanent horseshoe magnet F. When a current passes through the coil, the ends of the projecting core assume polarities similar to those of the adjacent poles. In consequence of the repulsion between the poles of the electro-magnet and the permanent magnet, the bobbin E will be thrown out of position, and the further end of the frame will be depressed proportionally to the amplitude of the movement of the bobbin. This may be limited, if desired, by fixed stops. When the current is interrupted, the magnet E is unmade, and the attraction of F for the soft-iron core restores the electro-magnet to its former position, thus bringing the paper again in contact with the helix.

The current which produces this motion in the frame, and which consequently traces the letters of the message, proceeds not from the sending station, but from a local battery connected with a relay. This relay consists of a fixed steel magnet and of an electro-magnet, the core of which is in proximity to the poles of the permanent magnet.

As soon as the synchronism of the two instruments is established, the helix B in each apparatus is at a point, which is called the reproducing point, the position of which exactly corresponds with that of C on the circumference of the transmitting cylinders; that is, if the point C passes over the beginning of a line of the manuscript despatch, the reproducing point will be at the edge of the strip of paper. In the same manner, all the points passing under C correspond to the same points of the line of the facsimile under the reproducing point. When C touches the metallised portion of the paper, the current from the battery is short-circuited, and the relays keep the currents proceeding from the local batteries closed; the electro-magnets E are repelled, the paper is removed from the helices, and no impressions are produced. When C touches the non-conducting ink with which the message is written, the short circuit is interrupted, the current passes through the line to the relays, where, by the sudden removal of the coil it opens the circuit of the local batteries. The coils E are attracted, and the paper is pressed against the helical threads. When the cylinder A completes a revolution, the style C undergoes a lateral displacement of one quarter of a millimetre. The strip of paper at the same time advances an equal distance, and the point C, passing again over the insulating ink, transmits the current through the line. As the helix B and the cylinder A revolve in equal times, the new impression produced by the line current will be the continuation of the letters in the facsimile of the message.

The synchronism of the two instruments is established and maintained during transmission by conical pendulums K, of special construction, with very heavy bobs.

This apparatus is in use on the line between Paris and Lyons. As in every autographic or chemical telegraph, the rate of transmission is comparatively slow; in other respects it has given satisfactory results.

However ingenious this autographic telegraph of M. Meyer, we do not hesitate in giving precedence to the multiplex telegraph of that successful practical electrician. Indeed, this appeared to us the most remarkable contribution to telegraphy that we saw in the Exhibition; and in our opinion, it fully justifies the interest it there elicited.

It tends towards introducing a considerable change in our present system by simplifying the elements of telegraphy without in the least diminishing its

efficiency. While it reduces the number of distinct lines to a minimum, cutting down from our poles more than the three-fourths of their burden, it aims at increasing, at doubling and quadrupling, the work actually performed by a Morse or a Hughes' apparatus. The test of all theory being experiment, we shall give further down a few numbers, tending to show the services that may be rendered by this new apparatus.

The system is based upon the utilisation of all the currents or signals which, in a given time, may be sent through a wire, by transmitting them successively to several independent stations. In this way 20 or 30 messages may be despatched per hour through the same line by several operators as readily as if each commanded a separate line. The limit to the number of different transmissions which may thus be sent, is practically determined by the degree of conductivity of the wire. If we suppose an employé, operating with a Morse instrument, to send 25 despatches in an hour—the usual number—we may say that on an average he closes the circuit, or sends the current through the line, five times every second. Now, denoting by n the maximum number of currents that may be transmitted per second, we shall then have $\frac{n}{5}$ to represent the maximum number of stations that may be established, or in other words, the number of operators that may work together.

In the multiplex apparatus exhibited at Vienna, this number is four. The cylinders revolving on the axle G, fig. 52, are driven with a speed of 75 revolutions per minute; in each revolution they mark four letters, one at every receiving instrument. Each operator can thus send 4,500 letters in an hour. This rate of transmission requires five times four emissions of the current per second, and produces 100 despatches hourly. Various experiments show that more than 20 signals may be given per second through a good telegraphic conductor, and from this we are led to infer that the hourly rate just mentioned may be increased without inconvenience. Several trials have been made with autographic receivers, in which clear and very distinct impressions were obtained with a duration of the current equal to the one five-hundreth part of a second, almost an inappreciable point of time.

Fig. 52 shows the apparatus as constructed for four operators; a, a, a, a, are the keyboards used in transmitting, r, r, r, r, are the receivers, and p, p, p, p, strips of paper upon which the message is written by means of dots and dashes, the usual language of telegraphy. These impressions are made, as in the autographic apparatus, by the contact of a helical thread with the paper. The two cylinders of each apparatus receive their motion from a train of clock-work driven by the weight Q, and regularised by the conical pendulum R. The keyboards and the receivers are in electrical connexion with the battery by the distributor K, and also with the earth by a metallic conductor. One battery only is required, however numerous the stations may be.

The distributor, fig. 53, plays the most important *rôle* in this instrument. It is this ingenious piece of mechanism that, at equal intervals, sends the current to the operators (in the present case four in number) of the transmitting station, and from them to the employés of the receiving station. It consists of a metallic disc O, O′, which is fixed and carefully insulated. Its circumference is divided into 48 equal parts, that is, 12 to each quadrant. Of these 12, eight are grouped together two by two, as shown more clearly in fig. 54, and connected with the eight keys of the keyboard by so many insulated wires strung into a thin cable. The four divisions which remain are permanently put to earth. We thus see that there are four cables, each containing eight wires insulated from one another, and leading from the keyboards to the distributor. The double divisions, as K and O′, in fig. 54, are 16 in number; an interval, or short space, occurs between each pair. The first element of the couple, if we may so speak, as K, O′, being the one-forty-eighth of the circumference, gives a short contact; the whole couple v, O′, would afford a contact just twice as long. We shall presently see how the current may be sent through either or through both, thus producing the dot and the dash—the elementary signs of the telegraphic alphabet.

A small elastic contact u, fig. 53, is mounted on the axis G. It is carried round the circumference v, v, v, by the rotation of this axle, and puts the

four keyboards and receivers successively in communication with the line, so that any current, passing while the metallic piece *u* is on one of the quadrants, will be transmitted to the corresponding receiver. Thus, if *u* be rubbing against the third quadrant, the third keyboard will have the use of the line. From this it is obvious that each operator will have the current at his disposal only during one-fourth the interval occupied by the distributor in accomplishing one of its revolutions, that is, during the one-three-hundredth part of a minute, or one-fifth of a second; and further, that the simultaneity spoken of above consists, not in sending various despatches absolutely together, but in having several messages in course of transmission at the same instant.

The keyboard, or manipulator, consists of eight keys, four white and four black. These play between the battery and the earth-plate. By depressing a black key, the current from B passes through *g* to *v*, fig. 54; whilst if a white key be depressed, the current from the battery will divide at *f*, one portion going to K, O′, and the other through *g* to *v*. In the former case, the contact being short, we shall have a dot; whilst in the latter we shall have a dash. The Meyer alphabet closely resembles that of Morse.

To transmit a letter the operator presses down as many keys, black and white, as there are dots and dashes in that letter. Thus to send the letter *b*, which in this as well as in the Morse code of signals is — . . . it would be necessary to press down one white and three black keys. These must remain depressed, until a small metallic bar *c*, fig. 52, which is placed under the eye of the operator, and is worked by an eccentric, tells him that the letter is traced. As the motion of this bar is attended by a sharp click, the operator may manipulate without looking at the keyboard.

We have already said that the letters are traced by a helical thread, a portion of which may be seen on the cylinder A, fig. 55. It is always that fraction of the circumference of this cylinder that unity is of the number of transmitting stations. In the present instance, it is one-fourth. The four partial threads would, if put together, form a helix of sufficient length to describe one convolution round the cylinder.

The helix of the receiver and the contact *u* of the distributor revolve in equal times; and they are so arranged that while the latter glides over the first quadrant, the former passes in front of the strip of paper. Near each cylinder is placed a roller *r*, fig. 55, which is saturated with ink. The paper is gradually unrolled and pushed forward by the arm of a rocking lever, which is worked by the armature of an electro-magnet. The slip of paper follows the oscillations of the lever, the amplitude of which does not exceed one-tenth of a millimetre. This lever carries at one extremity a small electro-magnet, the core of which projects a little beyond the edges of the bobbin, so as to be within a few millimetres from the poles of a permanent magnet, bent in the shape of a horseshoe. So long as no current passes, the core is held by the attraction of the steel magnet; but on the completion of the circuit, opposite polarities are developed. These cause repulsion between the electro and the permanent magnets, which, in turn, is attended by the oscillations of the lever-arm. Therefore, as often as the current passes, the strip of paper is pressed up against the helix, from which it receives impressions proportional in length to the duration of the current.

The letters are traced from left to right, and only one in each line. This transversal arrangement has a twofold advantage; it prevents the confusion occasioned in the Morse system by the occasional contiguity of the letters, and it considerably reduces the length of the telegram strip. The lower portion of the paper *p*, fig. 55, shows the following letters *n*, *o*, *y*, *l*.

The synchronism of the apparatus, which is absolutely necessary, is maintained by a conical pendulum R, fig. 52, which regularises the train of clockwork. An irregularity equal to the one-thousandth part of a second would be sufficient to disturb the correct working of the instrument. To compensate for the variations that would inevitably occur, recourse is had to a system of correction, based upon the displacement of the centre of oscillation of the pendulum. The bob, which is arranged to slide freely along the rod, is suspended from a double spiral spring of determined elasticity. To the lower part of the bob there is attached a string, which winds around a thin cylinder.

According as this cylinder turns in one direction or in another, the bob ascends or descends, occasioning a corresponding retardation or acceleration in the apparatus. The axis of the cylinder carries on its other extremity a small disc, the whole being governed by an electro-magnet. Two cams, fixed to two wheels revolving in opposite directions, act upon the disc and produce the upward or the downward motion of the bob. By means of this double effect, the synchronism of both apparatus is maintained. Hence the two contacts will describe on their respective distributors similar and equal arcs, and any current passing through the wires of the first quadrant will work the first receiver, and in like manner for the others.

Each operator enjoys the exclusive use of the current and line-wire, both for transmitting and receiving, during a quarter of a revolution. He avails himself of this interval to send or to receive his letter. Only one letter can be sent for each revolution of the tracing helix. During the rest of the time, he is out of circuit, and cannot, in any way, interfere with the other manipulators or receivers.

The multiplex telegraph, which we have now described, has been placed, by way of trial, on the line between Paris and Lyons, when messages were sent from 11 a.m. to 6 p.m. We extract the following results from the official report of the commission appointed to test the efficiency of this apparatus :—

"The maximum number of messages sent by an operator was 28 per hour; "the maximum of the line was 110 despatches per hour; the average of each "operator was 19 messages per hour the first day, and 22 and 23 subsequently. "It is well to remember that the average with a Morse apparatus is 18 mes- "sages for each operator, and with a Hughes' 22. The average for the wire "was thus 4 times 23, or 92 messages per hour, whilst that of a Hughes' is "only 45. Each employé thus sent during the seven hours from 11 a.m. to "6 p.m., at least 150 messages, and the four employés the remarkable number "of 600."

A multiplex apparatus for four transmissions is at present in service between Paris and Lyons. One hundred messages are sent every hour through the same line.

We thus see that the exhibited apparatus does double the work of the Hughes, and four times that of a Morse. This multiple may be raised by increasing the number of receivers. The price of the apparatus may be roughly estimated at as many times that of a Morse as there are receivers.

During the Exhibition, messages were daily exchanged with the offices of the Austrian Central Administration. The average rate was 100 despatches an hour; the maximum reached was 120. Induced by such results the Austrian Government purchased the apparatus, an example which has since been followed by several other countries.

The telegraphic apparatus exhibited by M. L. d'Arlingcourt belongs to the autographic class. It consists of two cylinders revolving synchronously, and covered respectively with sheets of chemically-prepared paper and tin-foil. On the latter the despatch to be sent is written with insulating ink; the passage of the current determines on the former an electro-chemical tracing, which is an exact reproduction of the message.

The method by which the isochronous movement of the transmitting and receiving portions of the apparatus is secured, is novel and ingenious. Instead of the conical pendulum of Meyer's apparatus, M. d'Arlincourt regularises his trains of wheelwork by straight or coiled rods (figs. 56 and 57); not, however, in using their rectilineal, but their circular vibrations; and the synchronism of the rods being once established, it is maintained by the instrument itself. The error which may glide in cannot in any case be considerable, as the corrective action takes place at every revolution of the cylinders. One of these—the transmitter—is automatically brought to rest, in which state it must remain until a current from the receiver releases a little catch, and sets it rotating again. In the mechanical arrangements necessary to insure this immediate rotation, lies a considerable part of the originality of the apparatus. Two trains of wheelwork, shown in figs. 56 and 57, are so disposed, that they may act either separately or together. The train *a*, *c*, *d*, *e*, *f*, which is used solely to maintain the synchronism is connected with the rod

k, while the other *a*, *g*, *h*, *i*, *j*, carries at one end *g* either the chemical paper or the tin-foil, and also the micrometric screw *g'*, along which the tracing-point or style slides as it successively comes in contact with every point on the surface of the paper or foil. As the two trains do not necessarily work in conjunction, one of them—the autographic for instance—may be stopped without in the least disturbing the synchronous train. This is readily effected by the axle *a*, which is common to both systems, and which, as it plays an essential part in the proper working of this apparatus, we give on an enlarged scale in fig. 59; *a'*, *a*, is the axle, carrying at one extremity the pinion A, which gears into *g*, *h*, *i*, *j*, fig. 58, and at the other *a'*, the piece D, R, whose office we shall presently see. B, B', *b*, moves freely on *a*, *a'*; it consists of the pinion B gearing into the wheel-work *c*, *d*, *e*, and of the wheel B'. R, B' is a ratchet or spring which secures the joint movement of the axle and B, B'. The teeth of the ratchet wheel are so made that when *a*, *a'*, is brought to rest by D, R, the wheels, B', B', and the pinion B—that is to say, the synchronal regulator—still continue to rotate. When D, R, is released, the axle *a*, *a'*, is set free, and with it the train *g*, *h*, *i*, *j*, of the autographical section. The ratchet R at the same time abuts against one of the teeth of B', B', and immediately begins to revolve with the velocity of that wheel. The mechanism by which D, R, is stopped, and afterwards released, will be understood from fig. 58. E, E', is a lever carrying a cam F, which is effectual in arresting D, R. The end of the lever rests on the extremity of G, H, which arm carries the keeper of the electro-magnet M. As soon, then, as the transmitter stops, and current is sent from the receiving station, the keeper G is attracted, and E, E' assumes the dotted position E, E''; D, R, being thus released, begins to revolve together with its axis, and thus imparts motion to the train of wheelwork, which in its turn secures the practical synchronism of both parts of the apparatus.

We shall now examine the electrical connexions. The current that releases the transmitter is quite distinct from that which is sent to the cylinders, and its duration is only a small fraction of one of their revolutions. It is by means of *s*, L, L, figs. 60 and 61, that the same battery current is commutated, and made to fulfil this twofold purpose. This lever oscillates freely on its fulcrum L, and may assume the three positions *s* L *m*, *s* L *g*, and *s* L *t*, according as it comes into communication with the various points on the circumference of *n*, *g*, *o*. In the first of these positions, viz. *s* L *m*, the line-current, arriving at L, will be sent to the electro-magnet M, and will thus free the transmitting instrument, as explained above. In the superior position, viz., *s* L *t* (better shown in fig. 61), the battery current, passing through the binding screw, C, traverses *t* L, and reaches the line-wire at L. In this case the apparatus ceases to be receiving, and becomes transmitting. It is while the lever is in these extreme positions that the synchronous movement of the cylinders is regulated. In the intermediate position *s* L *g* the current is directed to the cylinders by the contrivances *r*, K, K. It must be borne in mind that the cylinders are in permanent connexion with the earth. When the apparatus is receiving, the lever is in the dotted position *s* L *g*, fig. 60. The line-current then passes from *g* to L on the horizontal plate K, K. This plate contains several divisions, all of which are carefully insulated from one another. That marked L communicates with the line S with the style, and *c* with the positive pole of the battery. The three prongs of the commutator *r*, K, are electrically connected with one another, but are insulated from the arm *r*, *j*. In the present case, the line-current arriving at L will pass from *g* through the first two prongs of the commutator, and thence through the metallic sector *s* and the style to the cylinder A, B, and to earth. On reaching the paper, it will decompose the preparation, leaving as a record of its passage a fine precipitate. The breadth of line will depend upon that of the corresponding letter in the original message; or, in other words, upon the duration of the current. When the style again meets the insulating ink of the written message, the current is sent into the line, and a part either of the same or of another letter is traced. The *ensemble* of these minute lines or tracings forms a message which is a perfect *facsimile* of the original.

The system represented in fig. 60 is practicable only for short lines. If used for considerable distances, it becomes necessary to introduce a relay, which

appendage requires the various modifications shown in fig. 61. The commutator is thrown into the position indicated by means of the handle *o*, *q*, fig. 57. The line-current is led from *g* to the central division on the plate K', K'.

As the first three prongs connect the segments marked L and R, the current will pass from L to R and thence through the binding screw L, R, to the relay, which sends the current from the local battery through B, B, B, to the commutator, and thence from the segment *j* to the style.

As all autographical instruments require a very rapid succession of currents, M. d'Arlincourt was obliged to devise an improved form of relay which would meet this condition, the ordinary relay being too much affected by return currents and by variations in the residual magnetism of the cores. In M. d'Arlincourt's relay, the magnetic action of the coils of the electro-magnet is used to attract the thin metallic piece or tongue, destined to complete the electric circuit, whilst the remanent magnetism, which has hitherto been an impediment to the proper working of relays, is used as a substitute for the ordinary antagonistic spring. To illustrate this, let E, C, D, in *fig. 62*, represents the soft-iron core of the electro-magnet. When a current traverses the coils, A and B become respectively the negative and positive poles. The intensity of magnetisation is greatest at the free ends A and B, and it diminishes as we approach the neutral line E, at which it is obviously a minimum.

Here at *p* is pivoted a small strip of steel previously magnetised. When the current passes, the south pole *a* is attracted by the opposite polarity of *m*, and at the same time repelled by *n*. Under the action of these forces, the free end of *a*, *p*, would move towards *v'*. But the coils C and D exert a magnetic influence on the same movable tongue, which is opposite in direction to the former, and also of greater intensity. The tongue *a*, *p*, will thus obey the latter force, and move from its position of rest over to *v*, with which it will remain in contact as long as the current is passing. When the current ceases, the influence of the coils instantaneously disappears; but it is otherwise with the soft-iron cores, their residual magnetism being considerably increased by the extra-current, which is developed at the moment of opening the circuit. The little magnet *a*, *p*, will thus yield to the force repelling it from *n*, and soliciting it to *m*. In this new position it will remain until the circuit is again closed, when it will move from *v'* back to *v*. The oscillations of *a*, *p*, are regulated by the two screws *v* and *v'*.

To suppress the return currents it is only necessary to regulate the relative positions of the points of *v* and *v'*, so that *a*, *p*, may remain stationary when the circuit is closed, and make a complete oscillation when the circuit is opened.

This relay has the advantage of requiring little or no adjustment, as every current must necessarily displace the movable magnetic strip in the proper direction for sending messages. It possesses considerable sensitiveness, and works with rapidity.

By the introduction of this relay the autographic apparatus which we have just described has successfully transmitted messages to distances of 560, and even of 740 miles.

M. d'Arlincourt also uses his relay for the purposes of a translation. The complete apparatus is shown in fig. 64, and the manner in which the correspondence between two distant stations is established is shown in fig. 63. A, A, is the translating relay, and is so arranged that the tongue or pallet L will make only half an oscillation in one direction when the circuit is closed, and a complete oscillation when the circuit is open. The pallets L and R are pivoted upon the two poles of a permanent magnet K, and therefore possess opposite polarities. When no current is passing, the residual magnetism of the cores retains L in contact with the screw T, while the inherent magnetism of R maintains it in contact with B. M is a sounder connected with the screw V and the local battery P. When at rest, the armature N is drawn to the insulated screw Y by the spring U; a thin wire connects N with the coils of B, B, which, on account of the movement and the sharp clicking sound of the pallet N is called the "whip" relay. The second part of the apparatus,

marked in the figure as receiving the Marseilles line, is identical with that which we have just described. The two sets communicate with each other by the wires F and F'. The first, F, puts the screw T in permanent connexion with the coils A', A'; the second, F', connects T' with A, A. Now let us suppose that the employé at Marseilles opens correspondence with the operator at London. The current will arrive at the magnet K', whence it will pass through the tongue L', the screw T', the connecting wire F', to the coils A, A, and thence to earth. As soon as the electro-magnet is made, L passes from its position of rest into contact with V, thus closing the circuit P and transmitting the current from M through V, and L, to the London line. By the action of the same current, N moves from Y to X, and thus closes the circuit of the local battery *p*, the effect of which is to keep R in contact with the screw O. When the electrical signal has been sent, L returns to T and N to Y. By thus breaking the circuit of the local battery, the pallet R is thrown over to S, and the London line is put to earth. After effecting the discharge of the line R returns to O as above explained.

The sounders form a valuable controlling apparatus, as they record in an audible manner whether the relays are properly working or not.

This relay is actually used in connexion with the various Channel and North Sea cables, and has for upwards of a year performed the work of translation between London and Marseilles.

It is in this simple way that M. d'Arlincourt, meets the difficulties of automatic transmission.

We have now finished describing those instruments which we selected for special details because they appeared to us representative of their class and typical of the present state of science.

It will be noticed that our remarks on certain branches have been rather succinct, and the explanation of this brevity is not the paucity of the exhibits, but that we found such a small amount of novelty that we were not induced to depart from the plan which we had traced out. This lack of originality occurred more especially in the case of optical exhibits. We may say that in many a department of the Exhibition there was a goodly array of mirrors, lenses, levels, theodolites, microscopes, polariscopes, and meteorological instruments generally; but only in a few instances—and pre-eminent among these were the lighthouse lenses described in the beginning of this report—did we detect in these radiant and radiating instruments other than improvements of secondary importance. We therefore contented ourselves with mentioning the names of the principal exhibitors. The deficiency in the acoustical groups was still more apparent, as it was not confined to a want of originality; there were but very few exhibits, and even these were the ordinary apparatus for the more elementary experiments on sound.

But the case was different with the electrical collections. These were numerous, embracing all the branches of electricity and magnetism, and including apparatus for theoretical research as well as for practical purposes. Of the former, we have described Jedlik's statical battery, Jamin's magnet, Geissler's latest tubes, and Planté's secondary battery; and among others that attracted our attention we may mention Wiedmann's reflecting galvanometer with new arrangements for physical and physiological laboratories, Edelman's magnetometer for the absolute measurement of terrestrial magnetism, and Hankel's electrometer for ascertaining the electrical state of the atmosphere.

Of the more practical class, there was a much greater variety, particularly of telegraphic instruments. Each nationality had an attractive collection, the great bulk being in every case the Morse in one or other of its protean forms. Autographic telegraphy was well represented in the French section by the apparatus of MM. Meyer and d'Arlincourt. The multiplex of the former gentleman meets the requirements of easy and rapid transmission, whilst the apparatus of M. d'Arlincourt and of G. Jaite deal satisfactorily with the important problem of automatic translation. The new reflecting galvanometer and the electrical pyrometers of Messrs Siemens Brothers are valuable additions to electrical science in general.

The requirements of active service have called forth a variety of military telegraphs, smaller d namo-electric machines, mine and torpedo exploders

fuses, and detonators, &c. The paramount importance of insuring safe transit over our railway lines, has led to three novel and ingenious applications of electricity. These are the electric block-system of Siemens Brothers, the automatic steam-whistle of Lartigue and Forest, and the magneto-electric signal-arm of the Austrian North-Western Railway Company. The necessity of diminishing the casualties of navigation has produced two new light machines of considerable power. These are the Gramme and the Hafner-Alteneck magneto-electric machines. The size and solidity of the former would permit its use not only in lighthouses, but on board vessels where its adoption as a head light would decrease the frequency of collisions and other catastrophes at sea. This machine is also constructed for electro-chemical purposes, in which department it has given important results. As the second apparatus was hurriedly finished for the Exhibition, it would be premature to venture an opinion on the ultimate effects that may be obtained by paying due attention to the just correlation of its several parts.

The wants of the physicist's laboratory and the desiderata of the lecture-room were not overlooked; and accordingly we were presented in the smaller types of the Gramme and Alliance Company machines with substitutes for our powerful galvanic batteries. We are gradually approaching the solution of the vexed problem of the cheap and easy production of continuous induced currents, and when we shall have severed this knot, then, and then only, can we say that the coils of Faraday have superseded the elements of Volta. The tendency to the disuse of voltaic electricity is constantly increasing, and this was evinced at the Exhibition by a great disproportion between the magneto and the galvanic exhibits.

In concluding our remarks, we may say that, waiving the deficiency which we have pointed out, the actual state of science was well represented at the Vienna Exhibition.

MISCELLANEOUS.

A large number of mechanical exhibits were found at Vienna, which cannot be conveniently classified under any of the foregoing sections, and while it is impossible, through want of space to notice more than a very limited number of these miscellaneous exhibits, there are a few of sufficient importance to justify us in grouping them together under independent titles. Obviously no order in the arrangement of these various notices is practicable.

Ice-making Machinery.

The making of ice by artificial means is a matter of rapidly increasing importance, not only on account of the increase it affords in our domestic comforts, but also on account of its usefulness in many manufacturing branches. The ice-making machine has already been of great service in breweries, as it renders the brewer independent of the supply of natural ice, while it may also be used for the direct cooling of the air and the wort. Besides, ice made artificially by machinery is colder, and therefore harder than much natural ice, a fact which has clearly been proved by experiments lately made, when equal weights of both artificially and naturally produced ice were placed in warm water of equal temperature, the result being that the former took more than twice the time for melting than was required by the latter.

At Vienna were exhibited three ice-making machines, one by Messrs. Siebe and West, of Lambeth, London, one by Messrs. Vaas and Littman, of Halle-on-the-Saale, and a third by the Actien-Gesellschaft für Fabrication von Eismaschinen, formerly Oscar Kropff and Co., of Nordhausen, Prussia. Messrs. Siebe and West's ice-making machine is represented in Fig. 5, plate 262.

The principle applied in this machine consists in the production of a cold temperature by means of the evaporation of ether, and of the continued use of the same ether without any significant loss. The machine consists of a refrigerator, a condenser, an air pump and an ice-making box. The machine works in the following manner: As soon as the air pump is put in motion, the ether in the cooling vessel evaporates, and, of course, absorbs heat from the tubes by which the cooling vessel is traversed. The ether vapour thus produced is forced by the air pump into the condenser, where under the combined influence of the pressure and the cooling action of the water circulating through the condenser, it resumes the liquid form and returns through a small tube to the refrigerator, in order to be there again changed into gas. This process is continued with the use of the same ether as long as the machine is kept working. The great cold produced in the cooling vessel acts on the fresh water to be frozen in the ice-box by means of a current of salt water introduced into the tubes which pass through. The temperature of the salt water decreases quickly on its way through the refrigerator, on account of heat being absorbed from it by the ether changing into gas, and it then circulates with a temperature considerably below the freezing point in the ice-box, round a number of iron or copper vessels filled with the fresh water to be frozen into ice. The salt water, the temperature of which increases again by coming into contact with the vessels containing the fresh water, is taken back to the refrigerator, where its temperature is again reduced. The process of freezing is thus uniform, self-regulating, and uninterrupted, until the fresh water has been changed into ice. The latter is then removed, and the vessels are filled again with fresh water, and are again exposed to the cooling of the brine current. These machines of Messrs. Siebe and West's are now constructed like horizontal steam engines; they are exceedingly simple and compact, and have a steam engine attached, or may be worked from an existing shaft. The ice is made in single cakes, weighing between 8 lb. and 100 lb., according to the size of the machine.

If these cakes are placed one upon the other, they freeze together, so that blocks of any size may be formed. It is stated by Messrs. Siebe and West that they can produce from 10 lb. to 30 lb. of ice with their machines for 1*d.*, and that 1 lb. of coal produces between 3 lb. and 10 lb. of ice. The time taken in removing the ice and refilling the freezing vessels for the next operation occupies from 30 to 60 minutes. Messrs. Siebe and West state further that a temperature of 50 deg. below zero Fahr. has been obtained with this apparatus, and that from 50,000 to 500,000 cubic feet of air may be cooled per hour to 30 deg. Fahr., or a smaller body of air to a lower temperature. The ice made by this machine at the Vienna Exhibition was beautifully clear and crystalline, as pure and hard as best American or Norwegian ice.

Examining now the two German ice-making machines, we find that their construction is in nearly every respect identical with each other, and, although based on the same thermodynamic principle, these machines differ nevertheless considerably from the English machine in appearance, as well as in working. The English machine appears a compact, thoroughly well-considered construction, whilst the German machines show a great number of tubes, and vessels, and cocks, which require a good deal of attention. The general *modus operandi* of the German machines is as follows: A boiler is partly filled with a concentrated solution of hydrochlorate of ammonia, which is heated, and ammoniacal gas is thus generated. This gas is forced through serpentine pipes in a condenser to a refrigerator, and from there it is admitted into the serpentine pipes of the ice-box. The ammoniacal gas is exposed on its way to the ice-box to a pressure of 8 or 10 atmospheres, whilst it is considerably cooled in the condenser, the serpentine pipe of which is surrounded by cold water, the results being that the ammoniacal gas becomes condensed to a fluid form. The serpentine pipes of the ice-box are surrounded by a solution of hydrochlorate of lime, and the liquefied ammoniacal gas, passing through these pipes, resumes its gaseous form, and absorbs heat from the solution of hydrochlorate of lime. The boxes with the water to be changed into ice are placed in the ice-box, and immersed in the solution of hydrochlorate of lime. The fluid gas evaporated in the serpentine pipes of the ice-box passes into an accumulator, where it is absorbed by the fluid freed from ammonia, from which the gas has been produced by heat, this fluid having passed from the boiler through the refrigerator to the accumulator. The fluid is then again forced back by means of a pump into the boiler, whence it passes off again as ammoniacal gas.

In order to show the manner in which this system has been carried out by the German makers, we have selected the machine exhibited by Messrs. Vaas and Littmann, of Halle-on-the-Saale, and of this engravings are shown in Figs. 1, 2, 3, 4, plate 262. The boiler A, Figs. 1 and 2, partly filled with concentrated solution of hydrochlorate of ammonia, is set in brickwork, in such a manner that the flame has to pass round the boiler before it gets into the flue; in this boiler the evaporating cylinder, which is a vessel consisting of several plates arranged above each other, is fixed. The boiler is provided with a safety valve, and the ammoniacal gas generated passes to the serpentine pipes of the condenser B, Figs. 1, 2, and 3, through the cock *a* and the tube 4.

The machine for making the ice is placed on the bedplate M, carried by a brick foundation, and upon this bedplate are fixed the two frames L and L^1 supporting the condenser B, Figs. 1, 3, and 4, this condenser being provided with serpentine pipes. The lower end of these pipes communicates with the gas vessel C through the tube 6, Figs. 1, 2, and 4. The condenser B carries on the top the water-tank I, Figs. 1 and 3, which supplies the water necessary for the working of the machine through the upper tubes 40 and 41 to the condenser, and through the lower tubes 37 and 38 to the serpentine pipes of the accumulator E, Figs. 1, 2, and 3. The gas vessel C is carried by the frame L, Figs. 1 and 4, and communicates with the serpentine pipes of the condenser B by the pipe 6. The gas entering the vessel C through pipe 6 passes through the pipe inside the vessel Fig. 4, and from thence through the pipe 7, 8, the cock *b*, and the pipe 9, 10, to the distribution cock *c*, on the ice-box D, Figs. 1 and 2.

The vessel F in which the change of temperature is effected is fixed on the bedplate, and is provided with two sets of serpentine pipes, through which the weakened solution of ammonia comes from the boiler by the pipe 16, 19, thence passing into the serpentine pipes of the refrigerator G, Fig. 2, through the tube 20, 21. The fluid, rich in ammonia, enters the vessel F at the bottom, through the tube 31, and passes off at the top through tube 32, 34, into the boiler. The serpentine pipes in the vessel are arranged in such a manner that the two fluids, the one rich and the other weak in ammonia, do not mix together, The refrigerator G, Figs. 1 and 2, fixed on the bedplate, consists of an iron vessel provided with serpentine pipes, through which the weakened fluid passes to the accumulator E, which is carried by the frame K, Figs. 1 and 3. This accumulator is made of cast iron, and contains a double set of serpentine pipes, through which water passes in order to accelerate the accumulation. To the top cover of this accumulator are screwed four tubes, 16, 24, 42, and 43. Through 16 the ammoniacal gas enters after coming from the ice-box, and is mixed up with the fluid in the accumulator, whilst the weakened solution of ammonia enters through 24 in order to absorb the gas.

The tube 42 communicates with the vessel T, Figs. 1 and 2, and is provided at the end with the valve *o*. This vessel is always under water, and serves for the removal of the atmospheric air from the apparatus. The tube 43 is provided with the cock *m*, and communicates with the pressure gauge. The bottom of the accumulator communicates through the tube 25, 28, with the pump H fastened to the frame L. The suction valve of this pump communicates with the accumulator, as before stated; whilst the delivery valve is connected with the vessel F for the changing of the temperature by the pipes 29, 31, Fig. 1. This pump (see Fig. 4) is worked by hand; the flywheel shaft carries also an eccentric for moving two agitators in the ice-box, in order to produce a uniform distribution of the cold by causing a constant circulation of the hydrochlorate of lime.

The ice-box D is an iron box placed in a wooden box, the space between the two being filled with sawdust. The iron box contains several sets of serpentine pipes, which are united by a tube at their lower ends, whilst the upper ends are connected with small tubes communicating with the distribution cock *c*, Figs. 1 and 2.

Having now given a detailed description of the machine, we shall next briefly state how the heat is abstracted, and how the machine is worked. We should at first consider that the ammoniacal gas has the property of being absorbed by water, the more energetically the lower the temperature of the water is, whilst, on the contrary, heat separates the ammoniacal gas entirely from the water. Another property of the ammoniacal gas is that it becomes fluid under a pressure of from 9 to 11 atmospheres, and at a temperature of from 77 to 86° Fahr. The changing into gas again of the fluid produced in this manner creates an intense cold. The gas required for this production of cold is separated by heat from the solution of ammonia in the boiler. The fluid in the boiler, from which the gas has already partly been separated, passes into the accumulator E, to which also the ammoniacal gas is led, and the fluid saturated in this manner with ammoniacal gas is pumped back into the boiler in order to again give off gas, and so on. For the continuous working of the machine three actions are therefore required, namely:—

1. The liquified ammoniacal gas, which, after having, by its reconversion to the gaseous form, absorbed heat from the circulating fluid in the ice-box, passes into the accumulator.

2. The weakened fluid passes from the boiler to the accumulator in order to unite again with the gas, and

3. The saturated fluid is pumped back by the pump from the accumulator to the boiler.

The ammonia passes from the boiler though the tube 3, 4, the serpentine pipes of the condenser, and the tube 5, 6, Figs. 1 and 2, to the gas vessel C, and from thence through the tube 7, 12, to the serpentine pipe of the ice-box D, and back again through tube 13, 16, to the accumulator. The weakened fluid passes from the boiler through the tubes 16, 19, to the serpentine pipes of the vessel F for the changing of the temperature, from there through tube 20, 21, to the serpentine pipe of the refrigerator G, and then through tube

22, 24, to the accumulator, where it is mixed with the gas. From the accumulator the pump forces the saturated fluid through tubes 29, 31, into the vessel for the changing of temperature, and from there through tube 32, 36, into the boiler. The chief attention in the working of the machine has to be directed to the regulation of the two cocks *c* and *k*, that is to say, to the cock for the admission of the gas into the ice-box, and to the cock for the admission of the weakened fluid from the boiler into the accumulator, the opening of the cock K depends upon the opening of the cock *c*, and the opening of the latter depends upon the existence of the fluid ammoniacal gas; it must not be opened more than to allow to pass so much fluid gas as is produced. On the other hand, the cock K must not be opened more or less than is required for the quantity of weakened fluid necessary for the absorption of the gas coming from the ice-box.

These machines are built in six different sizes, for the production of from 10 lb. to 1,000 lb. of ice per hour, requiring for the same time from 5 to 500 cubic feet of water, and from 5 lb. to 60 lb. of coals. The space occupied by the smallest machines is 6 ft. by 4 ft., and that required for the *largest is 45 ft.* by 20 ft. The ordinary shape of the ice produced by the machines is a square plate, $2\frac{3}{8}$ in. thick, $7\frac{1}{4}$ in. wide, and $29\frac{1}{3}$ in. long, and weighing about 20 lb.

Soda Water Machinery.

During the season of intense heat which prevailed at Vienna last summer, there were few points of greater attraction than the numerous pavilions from the marble counters of which iced drinks of almost every kind were dispensed. These pavilions were elegant in design, and were erected by Messrs. Dows, Clark, and Co., of Chandos Street, London. Besides being exhibitors, Messrs. Dows, Clark, and Co. were concessionaires for supplying American Soda Drinks in the Exhibition and grounds. For the purpose of meeting the demand, they had in the grounds a neat looking house of corrugated iron placed near the eastern extremity of the Industrial Hall, and which formed their factory. Here the aërated water and syrups were manufactured, and thence conveyed to the pavilions and marble stands before referred to.

From the first manufacure of aërated water at Geneva, by Gosse, towards the close of the last century, and its subsequent introduction into Paris by John Paul, a great amount of inventive talent has been expended upon the various apparatus for preparing and supplying the beverage. In America this has been especially the case, where the enormous consumption has led to the introduction of apparatus for serving soda water on draught, which has to some extent superseded the bottled trade. Amongst the first to conceive and carry out in practice this novel idea was the firm of Dows, Clark, and Co., and their enterprise has not been confined to the United States. At the Paris Exhibition they had their stands, and they have established depôts in London, where their iced soda creams can be obtained. The apparatus for the manufacture of these beverages consists, first, of the machine for making and bottling aërated waters, shown in Fig. 1, plate 263. It is a machine for generating the carbonic acid gas, and in it can be used either pulverised marble, or bicarbonate of soda, which is acted upon by sulphuric acid, the flow of which into the generator is regulated by the lever T. A is the body of the generator, B the reservoir for the acid, and D D the washers through which the gas passes, and is purified on its way to the water. E is the pressure gauge for ascertaining the strength of the soda water, and which indicates pressure in pounds per square inch. C is the opening through which the marble is introduced into the generator. P is the blow-off pipe, just above which is the handle for agitating the contents of the generator. The lower part R of the blow-off pipe leads to the waste tank. F is a safety valve, and H a pipe leading from the generator to the acid reservoir to equalise the pressure.

The cylinders for holding the aërated water are shown at C C, the pump Q being used to supply the water to either cylinder as desired. In the first instance the two cylinders are filled nearly full of pure water, and then charged up to a sufficient pressure, when the cocks K and L are closed. The

pipe J leads to the bottling machine, and when desired the aërated water is let on by turning either the cock N or M. When either cylinder is empty the cock is closed, and a further supply of water pumped in with the pump Q. The water is gauged in the cylinders by the small taps O O. After filling with water, the carbonic acid gas is let on by turning the cock as before, and by agitating with the handles, another charge of aërated water is made in a very few minutes, and with little trouble. The gas in all cases passes through the two washers D D, and is thoroughly purified. The generator and cylinders are made of thick copper, the former being lined with lead, and the latter thickly tinned with pure metal.

This constitutes the apparatus for manufacturing aërated water for bottling, but for supplying the stands where the ice drinks are dispensed from an apparatus, a modification of this arrangement is employed. In this case the machine for generating the carbonic acid gas is mounted on a frame by itself. A flexible pipe is attached to the washer D, the other end being connected to a portable copper cyliner which holds about 12 gallons. Two discs are placed across the interior, having apertures in them, and the charging and discharging pipe extends from the top nearly to the bottom of the vessel. Two pins projects from the sides of the cylinder by which it is suspended in an iron frame when being charged. When about to be charged the cylinder is first about two thirds filled with pure water; if desired to have it strictly soda water a little carbonate of soda is dissolved in the water. The cylinder is then placed upon the agitating rack, and connected by the flexible pipe to the gas generator. The gas being let in, and the cylinder oscillated on the pins, the water striking against the discs is broken, and the particles separated, so as to allow the carbonic acid gas to unite very quickly and thoroughly with the water. When sufficiently charged with the gas, which is determined by the pressure gauge, which should stand at 180 lbs. after the water and gas have been thoroughly agitated, the tap is closed, and the cylinder transferred to the place where the water is to be used. This American system possesses many advantages over the ordinary method of manufacture. The gas does its own work, and steam power is not required, the saving in labour being stated to be 50 per cent. upon the English system, and the saving in fuel being of course very considerable.

The apparatus for dispensing the iced beverages is shown in section at Fig. 2. In the centre is placed the can M, which holds the cream, and above which is the ice cutter, destined to reduce the block of ice G to the condition of snow. On each side are the copper tanks, in which are placed the syrup cans C C, and the cylinders E E, all of which are enclosed in a marble case A A. Directly above the ice shaver is the cover B, provided with silver-plated knobs, for convenience of removal to introduce the block of ice G and smaller pieces into the compartments containing the cylinders E E, and the syrup cans C C, as represented. The draught tubes J are connected with the cylinders by a pipe for dispensing the soda water, and below them are the syrup taps connected with the syrup cans. Underneath are the pipes furnishing the soda water, and also for leading off the waste water. Fig. 3 is a central cross section of this apparatus, which shows the ice cutter or shaver in position for working. A A is the marble case; B the cover to same; F is the ice-cutter box, which is made of galvanised iron; P is a vertical cylinder open at the bottom, with knives projecting from its surface, and openings in conjunction with the knives to the interior; G is a follower connected by a divided nut with the screw; O, on the opposite side, is another screw with similar connections; N is a fly wheel; M represents the cream can, with the valve and a wire by which it is worked. In operating the apparatus the fly wheel is turned and the follower presses the ice against the knives in the cylinder, which shave it off like snow. The ice falls into the cup beneath, and cream is added at the same time from the cream can by pulling the handle. To the ice cream thus quickly formed is added the syrup and soda water, the result being a very refreshing beverage, and one which has quickly become popular wherever it has been introduced. This apparatus is enclosed in an exterior casing of polished Italian marble, more or less elaborately wrought, according to requirement. At the front are arranged the silver-plated syrup taps and soda-draught taps, as seen in Fig. 2. The draught

tap J, seen in section, is very simple in construction and operation, and dispenses with the bottle or cup, and draws the soda water with considerably more gas in it than when drawn in the usual way. After putting the ice, cream, and syrup into the tumbler, the valve is opened, and the stream, escaping with full force, thoroughly mixes the compound. The edge of the tumbler is then brought against the under side of the projecting lever, the valve is opened still wider, and a larger stream, without force, will flow highly impregnated with gas.

Besides the portable cylinders filled with aërated waters, and of which there were 200 in use at the Vienna Exhibition, Messrs. Dows, Clark, and Co., supplied their pavilions and stands with the water in bottles. For this purpose they use the globe-stoppered bottle invented by Mr. Hiram Codd. The bottle is formed with a ring of india-rubber inside the mouth, and contains a glass ball. The orifice is effectually closed by the pressure of the carbonic acid gas against the glass ball, which presses hard up against the ring in the neck. The ball is easily pushed back when the bottle is to be opened, the stopper falling into an annular space formed around the interior of the neck of the bottle a few inches from the mouth.

Merryweather's Steam Fire Engines.

When the nature and extent of the Vienna Exhibition are considered, it will be seen that the precautions against fire ought to have been of something more than the ordinary character. During the early days of the Exhibition the provisions made in this respect were far from satisfactory, but when the various pumping engines were got to work, there was ample supply of water, and the exhibitors of fire engines did their best to render this supply available in case of necessity. Amongst those who gratuitously aided in this way is the firm of Merryweather and Sons, of Long-acre, who placed at the disposal of the Commissioners four of their powerful steam fire engines, named respectively the Conqueror, the Victoria, the Austria, and the Danube. The first of these engines is illustrated by Figs. 1, 2, 3, plate 268, and is one of Messrs. Merryweather's large-class double-cylinder engines of the Admiralty pattern. It is worthy of notice, as possessing several new features of construction, and as exemplifying the leading principles observed by the firm. The engine weighs barely 57 cwt., and has a pair of pumps $6\frac{3}{4}$ in. in diameter, and 24 in. stroke, and steam cylinders $8\frac{3}{4}$ in. in diameter, and the same stroke as the pumps. The pumps, as well as their fittings, are made of phosphor-bronze, this metal having been selected on account of its superiority over gun-metal, in point of lighter weight, with equal strength being obtainable with it. The boiler fittings are of the same metal. The boiler plates, engine frame, springs, &c., are of steel, the boiler tubes being of weldless drawn steel No. 18 gauge.

The engine under notice is fitted with a new arrangement of slide motion, designed by Mr. Edward Field and his assistant, which has been adopted by Messrs. Merryweather, the effect being a material increase in the speed at which this class of engine can be worked. In carrying out this arrangement, each engine is provided with a hollow main steam slide, which is, in fact, a small cylinder, and is worked by means of a rod attached to it at one end, and in connection with the twisted bar arrangement peculiar to these engines. This main slide is worked by its own engine, and shuts off the supply of steam to the cylinder at the completion of the stroke. Each of these hollow main steam slides has working within it a small piston with a rod attached to it, which is in connexion with, and is moved by, the twisted bar of the other engine. The rod of this small piston has two holes drilled up it for part of its length, for the purpose of allowing steam to pass to either end of the cylindrical slide, in order to complete its stroke, and so reverse the direction of the steam to and from the respective ends of the cylinder.

Steam is supplied to this hollow rod by means of a third slide worked by the same twisted bar that moves the main slide. The ports in the hollow rod are so arranged that they open communication between the third slide and the hollow main slide before each of the pistons of the engines has in

turn arrived at the middle of its stroke. It will thus be seen that No. 1 engine commences to throw over the slide valve of No. 2 engine for the purpose of starting its piston on its return stroke, before the piston of No. 1 engine has reached the centre of its stroke, so that by the time it has arrived at the centre it will have thrown over the slide valve of No. 2 engine and started its piston. No. 2 engine influences No. 1 in a similar manner.

By this ingenious and simple arrangement there is no loss of time at the end of each stroke, consequently an increased number of strokes per minute is obtained. The fact, that the speed and the amount of work done are both increased, has been proved by comparing the results of trials with this engine with those of one of Messrs. Merryweather's latest engines of the same size, but without Mr. Field's improvements. In the first place the new engine, with 100 lb. steam, does the same amount of work as the old engine with 130 lb. steam. In the next, with equal steam pressures, the new engine is found to give 20 lb. higher pressure in the pumps than the old. Lastly, about the same water pressure is obtained on a 2¼ in. nozzle that formerly was got upon a 2 in. nozzle. A further advantage obtained by the introduction of this slide jacket is, that either engine can be worked separately by merely placing the other at half stroke, and locking its main steam slide by means of a steel pin. This ability to work one engine independently of the other is a very important feature, for should one engine become temporarily disabled at a fire, the other would remain in perfect working order, and could be used independently. Several trials of the Conqueror were made previously to its being sent to Vienna. Steam was raised in from 7 to 8 minutes from cold water; a jet 2¼ in. diameter was projected to a horizontal distance of 320 ft., and water was pumped through a line of hose about 1,000 ft. long, with one pump and engine thrown out of gear, the whole of the results proving satisfactory.

The boiler, which is shown in vertical and horizontal section by Figs. 2 and 3 on plate 268, is constructed on the "Field" principle, and is of a kind well adapted for use on a steam fire engine. The sides of the fire-box it will be noticed are formed entirely of "Field" tubes clustered together, and we may mention that a boiler of this kind, 2 ft. 4⅛ in. in diameter by 4 ft high, has been found to supply steam and maintain the pressure, whilst the engine has been developing from 27 to 30 indicated horse power. The boiler also possesses the advantage that if the water is allowed to get low the only parts damaged are the tubes, and these all can be taken out and replaced in 14 hours. A single tube if damaged can be taken out and replaced in half an hour, or the hole can be plugged if preferred. In the boiler of the engine under notice, the tube and top plates and uptake are of Bowling iron, while the shell is of mild steel and double rivetted. The tubes are of solid drawn homogeneous metal, and the boiler, which is fully provided with all necessary fittings, is tested up to a pressure of 300 lb. per square inch

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Shand and Mason's Steam Fire Engines.

Amongst the steam fire engines in the Vienna Exhibition were several by Messrs. Shand, Mason, and Co., in which some noteworthy improvements have recently been introduced. These improvements have been made in consequence of the objections taken to the engines of this firm which carry a flywheel, are not stoked from behind, and have their valves so arranged as not to be so easy of access as they should be. A perspective view of the engine in which these improvements have been carried out is given on plate 267, the details of the valve arrangements also being illustrated. From the perspective view it will be seen that the engine, which is of the horizontal type, has a single cylinder, and is stoked from a footplate at the rear; it has no flywheel; the crank, however, is retained. Figs. 2, 3, 4 illustrate the manner in which the improved valve arrangements have been carried out, by which a continuous rotary motion of the crankshaft is obtained. The crank is assisted past the dead centres without the aid of

a flywheel, by means of a piston fitted on the slide rod, which latter is made to perform alternately the duties of a slide rod and a connecting rod. As a slide rod it is impelled by the crankshaft, whilst as a connecting rod the crankshaft is impelled by it. Fig. 2 is an elevation in part section, Fig. 3 a sectional plan, and Fig. 4 an end elevation, partly in section, of the arrangement for obtaining this result.

On the crankshaft of engines in which the steam supply is regulated by a slide valve, an eccentric is fixed for the purpose of giving motion to that valve. The position of the eccentric on the crankshaft is considerably in advance of the crank, and usually above 90 deg. Therefore, when the crank is at either of the dead centres, or at zero, the eccentric is in a favourable position for assisting the crank if auxilliary power was supplied to the slide when in this position. The slide would then become the motor of the crankshaft, the eccentric would act as the crank, and the eccentric rod would act as a connecting rod. Thus, when the engine crank is on either of its dead centres, the slide auxilliary would be in full action, and when the slide eccentric (or crank) was on either of its dead centres, the engine crank would be in full action. By turning these facts to account, Messrs. Shand obtain a continuous rotary motion of the crankshaft, not requiring the moving of the crank past its dead centres for starting, nor the momentum of a flywheel while in motion, as there are no dead points on which the engine would stop, and no part of its revolution at which it would not start. To obtain this auxiliary power the slide rod is prolonged through the steam chest into a small cylinder. On the slide rod and in the small cylinder is a piston, while there is provided in the steam-chest a small auxiliary slide, which is actuated by projections on it coming into contact with a projection on the main slide valve frame. The auxiliary valve is thus moved so as to admit the steam to, or release it from, the small cylinder, thus actuating the piston fixed to the slide rod, and through the slide connecting rod or crosshead conveying motion to the small crank, and thus applying power for assisting the main crank over its dead centres.

Referring to Figs, 2, 3, and 4, A is the steam valve; B, the frame enclosing that valve; C, a small auxiliary valve; D, the steam chest; E, a small auxiliary cylinder; F, its piston; G, the small crank for actuating the slide; H, the engine crank working in a crosshead; I, the engine cylinder; and J, its piston. The piston is shown at the beginning of its stroke, the crank H on the dead centre, the small crank G in position for opening the steam port K, and at about 100 deg. in advance of the crank H. During the time the crank H is on the centre, steam is passing through the small port L and along the pipe M to the end of the auxiliary cylinder E, and pressing the piston F in the direction of the arrow will move the crank H by the crank G past its dead centre into a position in which it has power. The crank H will then carry the crank G to its dead centre, and the slide A to the end of its stroke. Meanwhile the projection N on the sling B will touch the projection O, on the slide C, and push it across the port L, opening the same to the exhaust, and opening the port S at the other end of the auxiliary slide, and admitting steam to the other side of the small piston F, to repeat the action on the opposite dead centres, the two cranks thus continuing to assist each other, and maintaining a continuous rotation of the crankshaft P. The small crank G represents the usual eccentric for working the slide valve, its action being the same; but, to avoid friction, Messrs. Shand have reduced its diameter and call it a crank. Several of these engines have been built, and are giving satisfaction in Glasgow, Pesth, and Vienna.

Figs. 4, 5, and 6, Plate 267, illustrate another of these engines, the first being a perspective view, and the two latter an elevation and plan. We should premise that since the conflagrations that have visited Chicago, Boston, and other large cities of America, Messrs. Shand have built several engines for the Western States. Two of the engines exhibited were prepared from the same designs as those for America, one of them being the 1,000-gallon 3-cylinder equilibrium engine now illustrated, and which is the lightest engine yet made, taking into account the mechanical effect it is capable of producing. One of the chief features is the inclined water tube boiler, which is formed

of welded Bowling plates with angle iron joints, turned and fitted with bolts and nuts, and capable of being removed, giving access for examination, cleaning, or repairs. The internal cylinder is rivetted at the bottom to a shell, which forms the firebox, the cylinder having a water space round it and a combustion chamber, in which are inserted several rows of drawn steel tubes 1 in. in diameter, each row being fixed transversely over the other, and at an angle, so as to promote circulation. The upper part of the internal cylinder forms the chimney, and is fitted with a faced angle iron ring, by which means it is joined to the outer shell at top with bolts and nuts. This arrangement gives good combustion, the flame becomes fully developed, and in passing up through spaces formed by the rows of tubes is divided, and the heat absorbed. The evaporating power is such that 100 lb. of steam pressure per square inch is frequently obtained in 6½ minutes from the application of the light. The boiler stands vertically in front of the hind axle, resting on longitudinal frames, and it has a fire-door behind for stoking during transit, with platform suspended for stoker and fuel.

The pumping machinery consists of an engine with three steam cylinders, made of best cast iron, with the steam chests cast on, the slide valves being of the same metal. The cylinders are bolted directly with flanges on to the pump frame, which is of gun metal, and cast in one piece. The pump, with delivery and suction chambers, frames and bearings for crankshaft, extends beyond the frame with the covers to which the steam cylinders are bolted. A treble crankshaft of steel is fitted in bearings midway between the cylinders and pumps, having solid eccentrics forged on for working three simple slide valves. Each piston has two steel rods passing above and below the crankshaft, and connected directly to the trunk of each pump. Steel connecting rods are jointed to the bottom of the trunks, in which they vibrate, and drive the crankshaft for the purpose of governing the engines and actuating the slide valves, limiting the lengths of the strokes of pumps under all conditions with regularity of movement, and dispensing entirely by this means with the use of the flywheel.

The construction of the pumps is also favourable for the equality of motion, as the water enters directly through the pump without changing the direction in which it is drawn in and forced out. It enters through the large suction inlet, and passes through the suction valves, which are composed of india-rubber discs, disposed over circular gratings. These valve seats are fixed to the end covers of the pumps, forming the cover to each pump barrel, and also the valve seats, and the withdrawal of these covers gives free access to all the valves. The water is then taken up by the bucket (which also contains india-rubber valves), and is forced one-half by the bucket, and the remainder by the ram in the other half stroke of the piston, being delivered from all the pumps in the same manner into a pump-head common to all. It issues from four outlets with screwed stop valves for coupling the hose to places at the bottom of the pump head. A continuous and uniform flow of water is thus obtained.

The engines and pumps, as will be seen from the engraving, are fixed with the cylinders adjoining to and in front of the boiler, resting on the side frames and laid at an inclination of about 16 deg. The lower end of the pump being fixed to the fore part of the carriage adds strength to the structure and gives freedom of access to the covers and suction outlet, so that firemen who are engaged coupling on the suction do not interfere with those joining on the hose. The feed pump, injector, and all boiler fittings are of gun-metal, and the steam and exhaust pipes of copper, connected from the three cylinders into one pipe. This engine is fitted with all necessary heating and emptying pipes for use in the severe winters of Canada and Russia, and the general arrangement is based upon several years' experience of the working of engines made by this firm in the above countries as well as in eastern and northern Europe. The engine illustrated is capable of working at from 30 to 200 revolutions per minute, using the smallest or the largest jets. It can be stopped and started at any part of the stroke, requires little attention, is said to work with ease and regularity through lengths of hose of 1,000 ft., and to have projected a jet 2¼ in. in diameter 300 ft. horizontally.

Besides the foregoing, Messrs. Shand had at Vienna an engine having pumps of similar construction to the one we have been describing, but placed vertically and behind the boiler. The valve arrangements are also similar to those just described. A fourth engine is of the same type as the last, but has a single cylinder. Messrs. Shand had also one of their manual engines in the Exhibition for 22 men. It was the lightest of its class that had then been constructed, weighing only 1,600 lb. Altogether, Messrs. Shand, Mason, and Company, had a very interesting and well-made collection of fire engines at the Vienna Exhibition, for which they obtained a prize medal.

Reinhardt's Fire Engines.

Mr. J. H. Reinhardt, of Würzburg exhibited at Vienna two hand fire engines, one of which is fitted on a four-wheeled carriage, to be drawn by horses, whilst the other is fixed to a two-wheeled hand truck. The former of these fire engines is shown in Figs. 1, 2, 3, 4, 5, 6, Plate 266. Both engines are double-acting, and the larger one has two plunger pumps with barrels $4\frac{3}{4}$ in. diameter (122 mm.) with a stroke of $8\frac{5}{8}$ in. (218 mm.), the corresponding dimensions of the smaller engine being $3\frac{5}{8}$ in. (92 mm.) and $7\frac{7}{8}$ in. (200 mm.). The chief peculiarity in the construction of these fire engines consists of the arrangement and handiness of the valves and the inner spaces of the cylinders; the former can be taken out without the aid of any tool and without emptying the water tubes, and can be cleaned and put in again within but a very brief delay, a considerable advantage when any sandy or impure water has to be pumped.

The arrangement of the pumps and valves is shown in sections and plans in Figs. 1, 2, 3, 4, and 5, and consists of the box K, containing the barrel of the cock *g*, and to which are fastened the two cylinders C C, the air vessel W, and the admission and delivery pipes. The box K is connected with the iron frames *a*, by means of the four bolts *v*. The plug of the cock *g* is hollow, and contains the two admission valves *e* and the two delivery valves *d*, and by means of turning the cock 180 deg. and bringing the opening *o* to the one side or the other, the pumps are made to draw the water either through the pipe *q* or the pipe *r*.

The pipes *q* and *r* are fastened to the box K, which is cast, as will be seen from the engravings, in one piece, and to which is also fastened at the bottom the air vessel, whilst the delivery pipe is at the upper end of the box. The plug of the cock *g* is pressed down in its place by means of the lever *s*, which is provided at its end with an eccentric nose acting against the stay *b*. This stay can be turned down (the screw bolts, by means of which it is fastened to the box K, acting as pivots), and this being done, the barrel of the cock *g*, with the valves *d* and *e*, can be at once taken out and easy access is obtained to all working parts of the pumps. It would, however, we think, be an improvement to increase the height between the suction and delivery valves, and to raise the pump barrels, so that the latter might more readily clear themselves of any sand which might get into them. The parts above described, it will be noticed, are placed above the water tank, so that any leakage is found out at once. The arrangement offers also great facilities for the cleaning of the valves, and for warming in case of a freezing in of the water, is shown in Fig. 7, Plate 266.

As the pumps are arranged on the same principle as those above described in the second but smaller type of this exhibitor's machines, and the illustration makes all further description unnecessary, we need only add that the diameter of the pump cylinder is $3\frac{5}{8}$ in., the stroke $7\frac{7}{8}$ in., and that eight men are required for working the engine. In concluding this notice on Mr. Reinhardt's fire engines, we should state that, with the slight improvement pointed out, they would be amongst the best we have seen on the Continent; the various parts are very handily arranged, and nothing can be said against the workmanship or materials.

Needle Stamping Machinery.

Mr. George Printz, of Aix-la-Chapelle, exhibited at Vienna an ingenious machine for stamping needles automatically; this machine, which is the invention of Mr. Francis Kayser, of Jserlohn, being capable of being driven by steam or water power in place of hand, like ordinary needle-stamping machines. In making needles, the lengths of steel wire from which the needles are to be manufactured require to be flattened at the part where the eyes are subsequently to be formed; and in the machine of which we are now speaking the lengths of wire are placed horizontally in a funnel-shaped hopper having vertical ends, and with sides sloping towards one another from the top to the bottom of the hopper. At the bottom of the hopper is a roller having longitudinal channels cut in it, each of a depth to receive one of the lengths of wire. A step-by-step revolving motion is given to this roller, and at each step one of the wires is delivered from the hopper and falls down horizontally on to forks which support it in front of a fixed bed or matrix; a hammer or stamp is then thrown forward against it by a powerful spring, and the wire is flattened between the bed or matrix and the stamp. Afterwards the stamp is drawn back by a cam, and the stamped needle is thrown out by a moving finger or wiper from the fork in which it previously rested.

The giving a step-by-step motion to the channelled roller, the drawing back of the hammer or stamp, and the working of the finger or wiper for ejecting the stamped needles, are all effected by cams on one shaft, and this shaft is supported in bearings on a frame, which also carries the hopper and fixed bed or matrix before mentioned.

Figs. 6 and 7, plate 263, show opposite side views of the needle-stamping machine; Fig. 8 shows a front view, and Fig. 9 a plan. In these figures A is the horizontal frame of the machine supported on standards B; C is the driving shaft supported in bearings D, and carrying the cams for imparting motion to the several parts of the machine. This shaft receives motion from a belt working on the fast and loose pullies C^1, and has fixed upon it the cams C^2, C^3, C^4, and C^5; the cam C^2 draws back the stamper or hammer E. The cam C^3 gives a step-by-step revolving motion to the grooved roller F; the cam C^4 actuates the wiper or finger for ejecting the stamped wires, and the cam C^5 moves the wires endwise up to a fixed stop previous to their being stamped; G is the hopper into which the lengths of wire to be stamped are placed; this hopper and parts connected with it is shown on a larger scale at Figs. 10 and 11; it has vertical ends, whilst the sides incline downwards towards one another.

The bottom of the hopper is closed by the grooved or channelled roller F, the grooves in which are each of a depth to hold one wire; on the axis of this roller is fixed a ratchet wheel F^1, and this has a step-by-step revolving motion imparted to it from the cam C^3. For this purpose the cam acts upon a roller on a sliding rod K, the end of which is adjustable and can be raised or lowered by turning a screw, as shown. This adjustable end piece acts upon the inclined end of a lever H, which lever carries a pawl engaging with the teeth of the ratchet wheel F^1; the amount of motion given by the cam C^3, to the grooved roller is adjusted by raising or lowering the adjustable end of the rod K.

As the lengths of wire are carried round in the grooves of the roller F, they are delivered one by one into the wire forks L, which retain them in front of the fixed bed or matrix M until they have been stamped. The cam C^2 acts upon a projection upon the stem of the hammer E to draw the hammer back until the cam arrrives at such a position that the projection on the stem of the hammer is free from it; the hammer is then thrown forward by the spring N towards the fixed bed or matrix M.

The strength of the blow can be adjusted by compressing the spring more or less by the screw N^1; and after each wire has been delivered by the grooved roller F into the forks L, and before it is struck by the hammer, the slide O is by the lever O^1 and an interposed spring caused to act against the end of the wire, and hold the latter up to a fixed stop, the lever O^1 being acted upon by the cam C^5. The hammer is then thrown forward

against it by the spring N, as before described, and afterwards the stamped wire is thrown out from the forks L by the fingers P; these are mounted on an axis P^1, which is caused to rock each time that a stamped wire is to be ejected. For this purpose the cam C^4 acts upon a lever Q which by a connecting rod Q^1 is connected to a lever arm on the axis P^1; the grooved roller at the bottom of the hopper containing the lengths of wire is then caused to turn one step, as before described, and deliver another length of wire to be stamped, when the same operations are repeated.

Tide Register.

The ingenious instrument which is shown in Figs. 1, 2, 3, plate 264, is one designed by Mr. F. H. Reitz, civil engineer, Hamburg, for the purpose of obtaining an accurate determination of mean sea level, a level which forms the zero point for so many important measurements. Before entering on a description of this instrument, of which a drawing was exhibited at Vienna, we may give a few general remarks on the calculation of the average level of the sea from observations.

The law of the rising and falling of the level of the water produced by the attraction of the celestial bodies, as it occurs in the open ocean, can be ascertained from theoretical considerations, the wave of the tide being represented by a curve of sines. It has been found, however, that, departing from the result of this theoretical investigation, the waves of the tide really observed have entirely irregular forms, Fig. I showing a few diagrams of such waves as taken by Hübbe in 1844. The line of sines of the same height and width is drawn in dotted lines in order to show more distinctly the irregularity of the curves.

The causes for the deviation of the form of tidal waves, as observed on the coast, from that found by theory, are chiefly the influence of the wind, the situation of the coasts, and the quantity of water supplied by large rivers.

The average level of the sea, that is to say, the level that would exist if the undulating motion of the tide was not taken into consideration, has to be deduced from the entirely irregular rising and falling heights of the sea. The line of the undisturbed wave of the tide is the line of sines. Supposing that in Fig. 2 the times are represented by the abscissæ, the corresponding levels of the sea by the ordinates, and a line $a\,b$ is drawn through the centre e between the highest level c and the lowest levels f and n, we find from the character of the line of sines that the surfaces $a\,f\,g\,k$ and $m\,d\,n\,b$ are equal to the surfaces $k\,h\,c\,e$ and $m\,i\,c\,e$; if the form of the wave should alter and if the water line became a straight line it would thus coincide with $a\,b$.

Under the supposition, therefore, of an undisturbed development of the waves of the tide, the average level of the water is in the middle between the highest and the lowest level, and could, therefore, be found from these data. This is, however, not the case on the coast, for reasons mentioned above. Designating the distance between high and low water by h, the rising of the average level of the water above low water by m, we find for the undisturbed tidal wave,

$$m = 0{\cdot}5\ h.$$

A larger number of observations have shown that for Cuxhaven $m = 0{\cdot}527\ h$ while from the diagrams shown above it is found that for Southampton $m = 0{\cdot}564\ h$; and for Ipswich $m = 0{\cdot}471\ h$.

The observation of the alterations in the level of the sea, produced by the motion of the tide, are often limited to the noting of the highest and lowest level for each tidal wave; but as stated already above, the average level of the sea cannot be ascertained in this manner. At some stations on the coast the levels of the sea are now measured by self-registering water-level recorders, which give the levels for any time, and which consist of a cylinder with a vertical or horizontal axis moved by clockwork, upon which the levels are marked in a reduced scale by a steel or diamond point moved up and down by the water.

If Figs. 6, 7, plate 264, represents a diagram taken with a registering water-level recorder, and if the average level, designated here by *e o*, has to be found for the time from 12 to 12 (in the figure represented by the distance *a b*), the position of the line *a b* has to be determined in such a manner that the surfaces below the line, viz., *a f g k* and *m d n b*, are equal to the surface above the line, namely, *e k h c i m e*. The line *a b* would then coincide with the surface of the water if with an unaltered quantity of water the wave of the tide should disappear. In other words, the surface *o f g k h c i m d n o* has to be made a rectangle, the base of which is *a b* or *f n*. The height of this rectangle is the average level of the water above the lowest point *f* and *n*.

For several reasons, tides vary much, whence it is no longer sufficient to ascertain the average level of the sea from a few diagrams only, whilst it is of great interest to ascertain whether the level of the sea alters in the course of years. Now, the uninterrupted work and investigations connected with the determining of the average level of the sea are tedious and difficult, and in order to facilitate such observations, the instrument which we are now going to describe has been invented by Mr. F. H. Reitz; it acts automatically, and with great exactness.

Fig. 1, plate 264, shows the apparatus in side elevation, end elevation, and plan in half size, and of the dimensions which should be adopted for European coasts. The apparatus is constructed in the following manner:—

From a float moving perpendicularly up and down in a well, or in a vessel of copper or iron, a metal wire passes over the pulley *a*. If the float goes down, this metal wire turns the pulley *a*, but if the float ascends the pulley *a* is turned into an opposite direction by means of a cord running over the pulley *b*, and carrying at one end a weight. A double-threaded screw *p* is fastened upon the axis *d* of the pulley *a*, whilst the screw *p* carries the nut *e*, which is connected by an arm *c* and the crosspiece *r* with a frame *x*, carrying the bearings for the roller *i*. The frame *x* turns round the points *q*. The roller *i* rests upon the glass disc *f*, upon which it moves in a radial direction, whilst the disc *f* itself is turned around its own axis once in 24 hours by means of clockwork and a disc *v*, with gearing on the circumference, into which is working the screw *s*, moved by the clockwork. A metal spring plate *z*, which can be tightened by screws *u*, and which bears on the point of the supporting centre, serves to diminish the force necessary for the turning of the glass disc, which is supported by three brackets *y*. The nut *e* is prevented from turning round with the screw *p* by the projection *n*, which is pressed by the weight *m* against the metal guide *o*. Counter-weights *k* take off any play of the screw *p*. The whole apparatus is fixed upon an iron plate *w* which offers a secure foundation.

Theory of the Apparatus.—At any level of the water the wheel *i* is in the centre *g* of the disc *t*, and if the water rises the wheel advances gradually towards *h*, and further. At each revolution of the pulley *a*, the level of the water has altered to the amount of the circumference of that pulley, which quantity we will call P. If H is the increase of the water level for the travel of the wheel from the centre of the disc, *g* to *h*, and S the pitch of the screw *p*, we get

$$(1)\ g\,h = \mathrm{H}\,\frac{\mathrm{S}}{\mathrm{P}};\ \mathrm{H} = g\,h\,\frac{\mathrm{P}}{\mathrm{S}}.$$

In the apparatus shown in the illustration, P is equal 1,000 millimetres, S equal 20 millimetres; *g h* would thus be in this case equal to $\frac{1}{50}$ H. Multiplying, therefore, the distances of the point of contact of the wheel *i* from the centre *g* of the disc *t* by the coefficients $\frac{\mathrm{P}}{\mathrm{S}}$, we get, according to equation (1), the corresponding rise of the level of the water.

For the understanding of the apparatus it is necessary to demonstrate how much any point of the circumference of the wheel *i* is moved through the united action of the changing levels of the water, and the turning of the disc *t* by the clockwork.

If the circumference of the wheel i be denoted by J, the number of revolutions of the wheel U, then the motion V of a point of the circumference of the wheel is,

$$(2)\ V = U\ J.$$

The motion $d\,V$ of a point of the circumference of the wheel i in an indefinitely small portion of time, if the wheel is at a distance D from the centre of the disc t, and if the arc corresponding with the indefinitely small portion of time, and through which the disc t is turned by the clockwork, is called $d\,\phi$, is

$$(3)\ d\,V = D\,d\,\phi.$$

The point of the circumference of the wheel travels in the indefinitely small portion of time as much as that point of the disc t at which the wheel touched the disc at the beginning of the same small portion of time; this travel is equal to $D\,d\,\phi$.

The whole motion V of a point of the circumference of the wheel in a certain time which corresponds with the arc ϕ of the circular motion of the disc is thus

$$(4)\ V = \int D\,d\,\phi\ ;\ \text{this is according to equation } (2) = U\ J.$$

Examining now this expression for the motion of a point of the wheel, as given by equation (4), it will easily be seen that this expression represents the area of a surface formed by taking the distances of the wheel from the centre of the disc t, and which are designated with D as ordinates, and the corresponding arcs of time for the radius l as abscissæ. The average D is found now from this area by dividing the corresponding length of the abscissæ in the present case by ϕ. Designating the average D by M, we get,

$$(5)\ M = \frac{\int D\,d\,\phi}{\phi};$$

substituting this equation $V = U\ J$ according to equation (2) for $\int B\,d\,\phi$, we get,

$$(6)\ M = \frac{U\ J}{\phi}.$$

In order to find the average level of the water, the value of M of equation (6) has, according to equation (1), to be multiplied by $\frac{P}{S}$; calling this average level of water m, we get finally,

$$(I.)\ m = \frac{P}{S}\ \frac{J\ U}{\phi}.$$

All the constant factors in this equation are to be determined by direct measurement, as well as by observations. Designating by C the constant factors in equation I., namely, $\frac{P}{S}J$, we get,

$$(II.)\ m = \frac{C}{\phi}U.$$

In order to determine C, the pulley a has to be fixed in such a manner that the position corresponds with a certain level of the water, m. According to equation (II.), we have:

$$C = \frac{m\,\phi}{U},$$

whence C can be calculated.

The equation (II.) shows how to find from the reading U of the instrument the average level of the water m; a table has to be calculated for the value $\frac{C}{\phi}$, which may be made into a round number for a minute or hour, perhaps 10 or 100. For 24 hours ϕ is $= 2\,\pi = 6{\cdot}2832$.

Adjustment of the Apparatus.—It is necessary that the axis of the wheel i should be parallel to the direction of its radial motion, thus with the axis of the screw p, in order to ascertain this parallelism, the wheel i is made to pass over the disc t when out of motion, by turning the disc a, whilst the

wheel *i* is not allowed to turn round. The adjustment is effected by turning the screws *r*.

Finally, it is necessary that the motion of the point of contact of the wheel *i* over the disc *t* should pass through the centre *g* of the latter. That is ascertained by a gauge, which measures the distance from the end of one of the arms *y* to a point of the frame *x*; the necessary adjustment is effected by means of the screws *q*. The screw *f* is used for fixing the wheel *i* for a certain level of the sea upon the centre of the disc *t*.

Use of the Apparatus.—The apparatus described above for determining the average level of the sea, requires very little superintendence; all parts of it are protected against dust by a covering of glass. The reading off can be carried out even by unprofessional observers. It is of advantage to choose the position of the wheel *i* in such a manner that the apparatus shows the differences with the average level of the sea known from former observation.

The apparatus described above can easily be connected with a maximum and minimum dial, or with an apparatus for indicating the wave of the tide; for this purpose a pinion is fastened on the shaft *d*, and brought into gear with a rack which carries the pencil. The cylinder for receiving the drawing is turned by the clockwork. This apparatus is manufactured by Messrs. Dennert and Pape, instrument makers, of Altona, and by M. Knoblich, chronometer maker, of the same place.

Diving Apparatus.

The Königsberger Maschinenbau Actien-Gesellschaft Vulkan, of Königsberg, in Eastern Prussia, exhibited amongst other things in the pavilion for the Prussian Iron and Mining Industry, at the Vienna Exhibition, some interesting diving apparatus as used on the eastern coast of Prussia, for obtaining amber. This apparatus, Fig. 4, plate 263, and which received a gold medal at the Moscow Exhibition of 1872, is constructed on the system of MM. Roux-quayrol-Denayroux, some alterations and improvements having, however, been introduced so as to give greater safety. The air is transmitted to the diver through long india-rubber tubes by means of an easily transportable air pump with two cylinders. These tubes, which are strengthened by spiral wires, conduct the air to a regulator carried on the diver's back. The completely air and water-tight dress of the diver is connected by an india-rubber ring with a copper helmet, or also with a mask, the helmet and mask being provided with strongly grated windows. The helmet is used for works under water in which the head of the diver has to be kept upright (repairing ships for instance), whilst the mask is adopted for researches and examinations on the sea bottom.

A great advantage of this arrangement is that the diver has always a certain reserve quantity of air in the regulator, so that a falling off in the supply of air is not connected with immediate danger or disadvantages for him. The supply of air to the diver is regulated by a peculiarly constructed valve, by means of which the pressure under which the air is supplied corresponds always with the depth of the water in which the diver is acting.

The air coming from the diver is not allowed to mix with the fresh supply of air, but escapes to the surface through a side-port closed by an india-rubber valve. The diver is able to increase or diminish his specific weight by simply altering the volume of air between his dress and body, and in this manner it is in his power to ascend or descend as he likes. Fig. 5, plate 263, shows a plan of the various details of the equipment, as exhibited by the Vulcan Company.

Salt Mill.

On Plate 264 is shown a self contained mill of substantial design which was shown at the Vienna Exhibition by Mr. G. Sauerbrey, of Stassfurt, Prussia, and which is specially intended for grinding rock salt, although it may be employed also for grinding calamine, broken glass pots or seggars, or other

materials of a similar character. It consists, as will be seen from Figs. 4, 5, plate 264, of a bed plate carrying a pair of standards which support the mill proper. The hopper, grinding cylinder, or "stone" and casing are chilled on their working surfaces so as to obtain durability, and the "stone" and its casing taper towards the top, so that the materials to be ground, which are thrown by the centrifugal force against the casing, are forced by the inclination of the latter against the grinding surface. The horizontal shaft, it will be seen, is provided with fast and loose pulleys and with a bevel wheel which is made to grip the shaft through conical wedges fitted as shown, so that it may slip in the event of too great a strain being thrown upon the mill. The vertical shaft is bored out from the top downwards for about a third of its length, and in the hole thus formed slides a bar which is connected by means of a cotter with the grinding cylinder of the mill. This cylinder slides on a feather on the vertical shaft, and by means of a screw at the top of the bar just mentioned, it can be raised or lowered so as to adjust it to any required distance from the casing.

Mr. Sauerbrey makes the mills described in three sizes, capable respectively of grinding 12 cwt., 20 cwt., and 30 cwt. of rock salt or similar hard material per hour. Of course, with softer substances the production is greater, and it depends to an important extent upon the dryness of the materials. The speeds at which the mills are driven vary from 25 revolutions per minute for rock salt to as high as 140 revolutions per minute when salt for manures and similar materials are being treated. The mill is of very creditable design and workmanship.

Osterkamp's Rock Drill.

Mr. Hermann Osterkamp, of Eschweilerpumpe, near Aix-la-Chapelle, exhibited at Vienna, the rock-drilling machine, illustrated by Figs. 4 to 8, plate 265. This rock-drilling machine consists essentially of a cylinder and piston, the piston filling the cylinder partially and being rendered air-tight by a packing made of five or more rings or recesses turned out on the surface of the piston. In the same manner the piston rod is kept air-tight in the cover or stuffing box through which it works. The drill is fixed to the outer end of the piston by a wedge. The other end of the piston rod is formed square, and embraces a rod which passes through the cover of the cylinder, and has a bevel wheel fixed thereon for imparting rotary motion to the piston. The piston at the same time works up and down the cylinder with the piston rod. The rotary motion of the aforesaid bevel wheel and piston and drill is effected by a second bevel wheel fastened on an axis which has a toothed wheel. The reciprocating movement of the piston is effected by the distribution of the parts and their construction, which essentially differs from drilling machines or engines as heretofore constructed. At the side of the aforesaid cylinder, and in connection with it, is attached a smaller cylinder fitted with a piston, the rod of which has two ports or passages formed therein, forming a slide valve for admitting and cutting off the compressed air as desired.

In the engravings, Fig. 1 shows a section of the cylinder and piston *a*; and Figs. 2 and 3 show the outside of the cylinder X. The piston *a* fills the cylinder partly, and works tight therein by an air-tight packing produced by five rings B turned out on the surface of the piston. In the same manner the part C of the piston is tightened in the cover *c* as in a stuffing box, and the drill is fixed at the end of the piston by a wedge at 1, the other end of the piston rod being formed with a square aperture to receive and embrace a rod, *d*, of the same shape. This rod passes through the cover of the cylinder and terminates in a bevel wheel, *e*, by which it can be turned round in the cover of the cylinder, turning at the same time the piston, which also moves up and down with the piston rod.

The rotary motion of the bevel wheel and piston, and the drill 2 fixed thereto, is effected by a second bevel wheel *g* fastened on the axis *f*, which has a ratchet wheel *t* fixed on it. At the side of the cylinder X and in connexion with it is attached a smaller cylinder *h*, fitted also with a piston, the rod *i* of which has at the back end two different apertures *k* and *l*.

When the pistons of the cylinders are in the positions shown at Fig. 1 the compressed air, which is the motive power to be employed, streams out of the tube in through the aperture *k* of the small piston into the working cylinder X, pressing the piston and with it the drill forwards until the upper end reaches the aperture *n*, then the air enters into the distributing cylinder *h*, pressing likewise the piston *o* forwards. The aperture *k* in the distributing rod then goes beneath the entrance A of the cylinder, and when the working piston continues its course to the fore end of the cylinder the opening *l* of the distributing rod comes against the entrance A, thus effecting the communication of the compressed air in the cylinder with the atmosphere.

At this moment the working piston goes backwards, driven by the compressed air of the common reservoir, which communicates without interruption with the lower part of the piston by the channel *r*. Immediately after the fore part of the piston has reached the lateral opening *p* the air goes also into the distributing cylinder, driving its piston backwards into the piston shown at *Fig.* 1, and also the piston in the cylinder X. This movement then begins again when the working piston goes forward, the compressed air which was before it returns to the reservoir, whilst the small volume of air which was working in the smaller cylinder passes through the small opening *g* into the open air.

On the back end of the distributing rod is fastened a pawl 3 for moving the toothed wheel *t* forwards at each stroke of the piston, and with it the axis *f* and the working piston *a*; a catch *u* prevents the wheel going backwards. The drilling machine is fastened to a support *b* by a wedge, and this support can be moved to and fro on a frame *e* by the screw *d* and the crank *c*. Two rods *f* fastened to the frame in combination with a third rod *g*, which can be shortened and lengthened to form a stand which in most cases is sufficient for the use of the machine without any need of fixing it otherwise. The moving forward of the drill is by the workman by means of the crank *c* on the screw *d*. The man who works the machine is always able without any difficulty and without the least loss of time to effect the moving forwards of the drill, and to accommodate this precisely to the degree of hardness of the rock. Figs. 4 and 5 give two views of one of these machines mounted on its support.

Filter Press for Porcelain and Pottery Works.

In all porcelain and pottery works, and in general in all washing operations of clay, porcelain, earth, chalk mineral colours, &c., the separation of the water from the prepared material is, when effected by the ordinary processes of deposition or evaporation, a difficult, tedious, and therefore expensive work. The former process requires great space for carrying it out, whilst the latter consumes a large amount of fuel. In order to get over these difficulties many experiments have been made, and various arrangements of filter presses have been introduced, Messrs. Needham and Kite, especially, having in this country been very successful in the construction of presses for the above-mentioned purposes. This firm was, we believe, not represented at the Vienna Exhibition, but in the Eastern Agricultural Hall an excellent collection of such presses was shown by Mr. A. L. G. Dehne, of Halle-on-the-Saale. Herr Dehne built these presses on two systems, either with vertical admission from the top outside supply pipe, and adapted for a lifting out of the residual cakes from the chambers; or with horizontal and central admission, inner supply pipe, and self-acting discharge of the residual cakes. The materials to be separated are introduced into the press itself by means of a monte-jus, or a pump specially constructed for this purpose, and attached to the press; this pump is worked either by hand or engine power. The presses themselves consist of a system of chambers, in which, through the pressure of the pump a filtration of the materials to be separated is effected, the separated fluid being discharged perfectly clear, and the solid stuff being formed into cakes, the density and fluid contents of which can be exactly regulated according to the requirements. The fluid is discharged through tubes, whilst the solid cakes may either be taken out of the chambers,

or be allowed to fall out. These two systems of patent filter presses, illustrations of one of which is shown in the Figs. 1 and 2, plate 265, are arranged in various ways, and are provided, according to the nature of the stuff to be filtered, with chambers made of iron, lead, metal, or wood; thus, for instance, acids come in contact with lead only. The presses are built in various sizes, and for various rates of production, varying for 12 hours' work, from 5 cwt. to 40 cwt.

The engraving represents a press, with vertical admission from the top and outside supply pipe, intended for separating the fluid stuff from washed porcelain earth. The latter is forced into the press by means of the hand pump, and passes through the flexible vertical tubes into chambers made of oak strengthened by iron bars; at both ends of these chambers cast-iron plates are placed, the front plate being stationary, and forming part of the frame, whilst the other is movable and is carried by two links. Between these two plates the oak chambers are fixed, these being supported at their sides by two bolts running from the front to the back plate. The fluid separated from the porcelain earth escapes, according to the pressure upon the material, through the small channels at the bottom of the chambers into a trough below, from where it is taken off in any convenient manner.

Pneumatic Sewage Pumps.

Mr. Ernst Hahn, engineer of Stuttgart exhibited at Vienna a transportable air pump for emptying the open cesspools which are still in use in many of the Continental towns. This sewage pump, which is illustrated by Figs. 9, 10, plate 265, is one of those adopted by the authorities of the city of Stuttgart; the *modus operandi* consists in pumping, by means of this machine, the air out of the wooden tubs or vessels in which the sewage has to be removed from the different houses; and the tubs being brought in connexion with the open cesspool by a flexible pipe provided with a screw valve the sewage is forced into the tubs. The machine, as will be seen from the illustrations, is mounted on a wooden platform carried on two pairs of wheels and mounted on springs, and is arranged for being worked by manual power. In our engravings, E is the air pump, A is the safety vessel for preventing any liquid from entering the air pump, and B is a small furnace through which the air and gases exhausted by the air pump are passed before escaping into the atmosphere. The air pump E, which works without dead space, is connected with the safety vessel A, by means of the pipe C, whilst the vessel A, which, as we said, prevents the fluid sewage from passing from the tubs into the air pump, is provided at the top with a flange, to which is fastened the suction pipe for the tubs. The air-discharging pipe D is connected to the furnace B as shown.

With the apparatus described a vessel of 2 cubic metres' contents can be filled, as stated by the manufacturer, within five minutes by two men. The machine with carriage complete weighs about 12 cwt.

Field's Pump Valves.

Figs. 8, 9, 10, plate 266, show a form of pump valve, designed by Mr. Edward Field, of Chandos Chambers, Adelphi, these valves being specially intended for use on pumps delivering against a high pressure, as, for instance, is the case with steam fire engines. These valves are each composed of two slightly coned india-rubber discs, placed face to face, Figs. 1 and 2, showing one method of mounting their discs.

In Figs. 8 and 9 the main body or casting is provided with ledges and abutments, against which the elastic valves are held by the cover-plates. The elastic discs are made quite flat, with central holes in them, and they are forced into and compelled to retain the conical form by being compressed and held by the inner edges as shown. The outer edges of the discs abut against each other, and are, of course, forced together by the pressure of the water upon their external surfaces. The casting on which the discs are mounted is held down in its place by a screw, a ring of leather or

india-rubber being used to make a tight joint round the opening G, which the valve closes.

Bernays' Centrifugal Pump.

Mr. J. Bernays, of 96, Newgate street, exhibited at Vienna the centrifugal pump shown in Figs. 6, 7, Plate 262, the leading feature in this pump being the arrangement by which the bearings are kept lubricated by the circulation of water. In ordinary centrifugal pumps, with the bearings situated opposite the suction openings in the pump disc, the water is drawn away from the bearings, and the latter are, through the want of lubrication thus caused, in many cases liable to get hot. To avoid this, Mr. Bernays has devised the arrangement shown by our illustrations. Referring to the latter, it will be seen that a small stream of water is caused to circulate through the bearings, the one end of which is placed in communication with the delivery channel, whilst the other end remains in connexion with the suction passages. Thus the difference of pressure between the suction and delivery chambers causes a stream of water to find its way through the bearings, and keep them perfectly lubricated. In the first pump that was altered to this arrangement, the effect was very marked, and practice has since shown that hot bearings do not occur in pumps fitted with these circulating pipes. The arrangement also prevents air being drawn in at the gland box.

The illustration shows an elevation and section of one of Mr. Bernays' pumps, as exhibited, and in which the circulating pipes are cast in one with the pump sides. A is the suction inlet, B B, passages for conducting the water to the centre openings of the disc. C is the working disc, which, according to Mr. Bernays' patent, forms two joints with the casing on both sides. One joint surrounds the suction opening, whilst the other is situated at the outer diameter of the disc, the object being to relieve the sides of the disc when at work from the pressure in the delivery pipe. The disc ejects the water all round into the circular delivery channel D, whence it is discharged through the opening E at any suitable point of the periphery. A bracket F with plummer block is bolted to one side of the pump, and carries the outer end of the spindle and the driving pulley. The circulating pipes G G for conducting the water to the inner bearings are cast to the sides of the pump, opening into the channel D at one end and connected to the bearings at the other. The pump shown was constructed by Messrs. S. Owens and Co., of Whitefriars Street, who are the makers in this country.

Guebhard's Automatic Counter.

A great number of ingenious arrangements have been proposed for registering the distance traversed by vehicles both on roads or railways. The common and very natural leading idea in most of these apparatus, is to count the number of revolutions of the wheels, from which the length of the route is estimated, and to effect this the apparatus receives its movement from one of the wheels of the vehicles. Such an arrangement of course involves an appropriate gearing, which is rendered very difficult by the play of the springs, whilst the constant shocks to which it is submitted wear and disorganise the delicate parts of the apparatus.

A French engineer, M. Guébhard, attached to the Eastern Railway Company of France, devised an instrument for showing both the times of movement and rest of a vehicle without the aid of any transmission of movement from the wheels. The invention is based upon the following observation: if, in a carriage, a band of paper revolves below a vertical pencil mounted free in a fixed support, this pencil leaves on the paper a very fine and almost invisible trace when the vehicle is at rest, and gives on the contrary a broad and well-defined line when the vehicle is in motion. It is the vibration due to the movement that thus intensifies the traces on the paper. Suppose then a drum, to which is given a uniform speed of rotation, by means of clockwork; around the drum a band of paper is rolled, and passes under the point of a

pencil, free to move vertically on its mounting. The hour is noted when the apparatus is set in motion, and the length of the strong lines and of the faint ones which are found upon the paper band after it has been unwound from the drum, indicate respectively the time employed in motion and in repose. The band may be divided with transverse lines into hours and minutes. The sketch, Fig. 3 plate 265, clearly explains the construction of the apparatus. It is possible to adjust the pencil and paper to any desired degree of sensibility, that is, the length of line to represent a minute can be varied at will. But to avoid the employment of too large a drum in the apparatus, which ought to run 24 hours consecutively, and to give the most accurate results, the pencil holder is mounted on a screw driven slowly by clockwork parallel to the axis of the drum, so that the marks left by the pencil during the successive turns of the drum, are not superposed, but form a helical line, which after the paper is lifted off, give a series of straight parallel lines, partly thick and partly fine. The value of a perfect apparatus of this kind is easily understood. On railways it is important in regulating the various conditions of the movement of trains. The time-tables prepared by the traffic agents rarely agree with the actual time made by the trains. The agents readily accuse the drivers of losing time, the latter explains generally such delays by the time lost at stations. If a train is stopped between stations from any accidental cause, it is interesting to know the time and the exact duration of the delay. The automatic register gives all these data with perfect accuracy. The Eastern Railway Company has largely adopted it, and finds that it works satisfactorily. The yard engines, amongst others, in the large stations are often employed with small economy, four engines being frequently used when three would be ample. The register will show how well each day's duty has been performed.

The delicacy of the apparatus is such that when one is in operation on a standing engine, the vibration of a passing train is sufficient clearly and distinctly to indicate the moment of passing.

The reading on the diagrams permit of the following facts being noted: if the delays in the station have been excessive, or if the times of arrival and departure are in accordance with the regulations. They show if the times given in the tables are exact, and in case of non-agreement, they show which is in the wrong, the time-tables or those in charge of the train. If the train has lost or gained time in the journey, the number of minutes lost or gained are recorded. They also show if the speed between stations has been increased, or if an engine has not made its speed, or has been stopped upon the line.

In road vehicles of all kinds, the route followed is of course not indicated, only the distance traversed, but the apparatus gives, however, most useful information. It shows, in fact, all the journeys made successfully, and all the stops, with the length of each, throughout the day.

For example, the diagram checks the movement of the vehicles which tradespeople and merchants employ for the delivery and transport of goods, and shows if the driver has made the proper time, and performed the whole of his work.

For public conveyances, cabs, &c., the counter gives the commencement and the end of each journey, and indicates each stop, and it shows plainly if the vehicle runs light or heavy. To do this a second pencil is placed in a porte-crayon attached to the seat of the carriage, when the latter is empty this second pencil is held above the paper without touching it, but when a passenger seats himself the pencil comes in contact with the paper and traces a line. In this case the parallel lines are drawn upon the drum, and from the number and length of these lines the number of fares taken and the length and number of journeys made during the day can be read off.

Hartig's Dynamometer.

In Figs. 4 to 8, Plate 268, is illustrated a dynamometer designed by Dr. Hartig, and constructed by the Sächsische Machinen-fabrik, of Chemnitz. This apparatus is intended to record, like Morin's rotary dynamometer, the

amount of work performed in transmitting motion to any machine, but it has this advantage over the instruments of Morin, Batchelder, or Wilde, that both its driving and driven pulley are in one vertical plane, and in connecting the apparatus none of the pulleys have to be shifted.

The dynamometer, which was exhibited at the Vienna Exhibition, belongs to the Polytechnic School of Buda-Pesth. The two shafts, A and B, are carried in bearings at the sides of the frame. On the projecting end of each shaft is a steel sleeve E, fastened to the shaft by a key and keyway, as shown, and on each sleeve is a fast and loose pulley C_1 C_2 and D_1 D_2. When the apparatus is employed, it is so placed that one of the fast pulleys, usually that on the shaft A, is connected to the transmission pulley by a strap, whilst the other fast pulley, also by a strap, communicates motion to the machine tested. On the shaft A there is a toothed wheel *a*, 13·937 in. in diameter, and with 34 teeth gearing into the wheel *b*, 29·567 in. in diameter, and with 102 teeth. This wheel *b* has an internal circle of teeth, 23.622 in. in diameter on the the pitch line, and 72 teeth. These gear with an intermediate wheel *c*, and communicate motion to *d*, which is 7.874 in. in diameter, has 24 teeth, and is keyed upon the shaft B. The respective numbers of teeth are such, that if the axis of the wheel *c* be kept from revolving round the shaft B, this latter must revolve with the same velocity and in the same direction as the shaft A, so that as the pulleys on both shafts are of the same size, the interposition of the dynamometer between the transmission and the machine to be tested, does not affect the latter in any way. The axle of the toothed wheel *c* is placed in the arm of a brake drum *e*, so arranged that it can turn round the shaft B. The arm opposite to that carrying the wheel *c*, is counterbalanced by the disc *e*. The boss of the brake is extended on one side to form a sleeve passing over the shaft B, and carries at one end, as shown, a toothed wheel *f*, 100 mm. = 3.93 in. in diameter, and with 30 teeth gearing into the vertical rack, as seen in the engravings, and to the lower end of which is connected a plate steel spring H_1. By means of the link *h* this spring is coupled to a second, H_2. of the same form and dimensions, and attached at J to the bed-plate of the machine.

From this arrangement we shall find that if a given quantity of work be transmitted from the shaft A to the shaft B, certain pressures will be exerted between the teeth of the gearing, and a certain force will tend to move the shaft of the intermediate wheel *c*, and with it the brakes and the wheel *f*, which will raise the rack *g* and deflect the springs H_1 H_2. This deflection may be measured, and this affords one factor of the value of work transmitted, while the velocity can be ascertained by counting the number of revolutions.

In order to record the deflections of the springs a band of paper is employed, moving at right angles to the direction of the deflection, and a pencil moving in the latter direction against the paper makes the record. In Fig. 6, K is a drum carrying the paper band, L is the drum against which the line is traced, M_1 M_2 are delivery rollers worked from the shaft A by means of worm gearing and a winding-up drum, moved by a small hand lever, as shown in the perspective view. The vertical rack *i*, moved by the toothed sector *k*, carries at its lower end the pencil *l*, which is pressed by means of a spiral spring against the paper on the recording drum L, and which traces a line, the ordinates of which taken from a datum line, show the deflection increased fourfold. A second pencil *m* fixed in the frame traces a straight line on the band of paper, which forms a base in measuring the diagram.

The brake blocks *o*, *o* can be pressed against the drum *e* by the two levers *n*, *n*, which turn on pins in the bedplate, while the upper ends are moved by means of right and left-hand screws, and a small crank, as shown in the perspective view. By this adjustment the operator is enabled to keep the wheel *c* in one position, which is necessary in order to prevent a sudden shock being thrown upon the springs. But after the machine to be tested is in steady work the action of the spring is obtained by releasing the brake drum *e* intermittently.

The mechanism for counting the number of revolutions is shown in the details Fig. 9. The stud V is screwed into the end of the shaft A, and has

a square-threaded screw q cut upon its outer end. This gears into the counting wheel W, which has 100 teeth, so that one revolution of the disc corresponds to 100 revolutions of the shaft A. An index r is provided, being attached to the frame, and in order to count numbers above 100, the following detail is introduced: On the axis of the disc W is a small eccentric s, and on it, concentric with the axis, is a disc t, with 10 recesses, as shown, and with 11 fixed pins u, u, also shown. When the disc W and the eccentric s have made a complete revolution from left to right, the disc t has made only one-tenth of a revolution from right to left. This disc is coupled by the pin v to a disc w divided into ten parts, freely turning on the shaft A, and the motion of this shaft is recorded by means of a fixed index against the disc w. The counting apparatus is controlled by the right-angled lever X, turning on the pin Y attached to the frame, and it is actuated by the handle Z, which can be moved through the limits shown at z, z.

Although the mode of using the dynamometer is very simple, the following remarks upon the subject will be found of interest. After the apparatus has been fixed in its proper position, between the driving shaft and the machine to be tested, both straps are put on, and strained until there is no appreciable slip. In order to secure this condition a preliminary trial will be necessary. To find the tension required for working the dynamometer, a diagram should first be taken, and it is advisable to take such a diagram before and after each trial, or at least any set of trials. After the preliminaries have been completed, the connexions for moving the paper and the counting mechanism are made.

The following is a theoretical consideration of the dynamometer:—

Let S signify the average pressure exerted by the pair of springs in kilogrammes.

r = the radius of the pitch line of the wheel f in metres.

u = the number of revolutions per minute of the shaft A.

Then the approximate amount of work E transmitted to the machine is

$$E = \frac{S}{2} \times \frac{\pi r u}{60} = \frac{S}{2} \times \frac{3{\cdot}1416 \times 0{\cdot}1\, u}{60} = 0{\cdot}002618\, S\, u$$

kilogramme metres per second.

But to obtain the exact value of E, it is necessary to substitute for S a corrected S′ in the above equation, and it is necessary to take into consideration the increased resistances called into existence when the machine is connected. In determining these a reference to Figs. 7 and 8 will be convenient. In these figures A and B are the two principal shafts, either of which may be the driving or the driven shaft, according to convenience, but as the resistances vary in each case, and affect the deflection of the springs, both must be treated.

The pressure P_1 between the wheels a and b is

$$P_1 = \frac{60}{75} - \frac{S'}{4} = \frac{S'}{5}.$$

The pressure P_2 acting upon the teeth of the wheels, b and c, and of c and d, is

$$P_2 = \frac{1}{2} \times \frac{S'}{2} = \frac{S'}{5}.$$

The pressure P_3 acting on the axle of the intermediate wheel c is

$$P_3 = 2P_2 = \frac{S'}{2}.$$

If u_1 = the coefficient of friction between journals and bearings, and

u_2 = the coefficient of friction between the teeth of the gearing we have the following results:

1. Friction between the teeth of the wheels a and b, reduced to the pressure of the springs:

$$S'_1 = 5\, P_1 \left(\frac{1}{34} + \frac{1}{102}\right) \pi u_1 = \frac{2}{51} \pi u_1\, S'.$$

2. Friction between the teeth of the wheels b and c:

$$S' = 4\, P_2 \left(\frac{1}{24} - \frac{1}{72}\right) \pi u_1 = \frac{1}{36} \pi u_1\, S'.$$

3. Friction between the teeth of the wheels c and d:

$$S'_3 = 5\,P_2\left(\frac{1}{24}+\frac{1}{24}\right)\pi u_1 = \frac{1}{10}\pi u_1 S'.$$

4. Friction between journals 0·06 metres in diameter of the shaft and bearings β_1, β_2:

$$S'_4 = 5\,P_1\,u_2\frac{0{\cdot}03}{0{\cdot}125} = 0{\cdot}24\,S'u_2.$$

5. Friction between the boss of the toothed rim b, and the shaft B 0·06 metres diameter. This friction arises in consequence of the angular velocity being only one-third that of the shaft B. The total pressure amounts to $P_2 - P_1 = \frac{S'}{20}$, and consequently the resistance reduced as before is

$$S'_5 = 4\frac{S'}{20}u_2\frac{0{\cdot}03}{0{\cdot}10} = \frac{3}{50}S'u_2.$$

6. Friction between the intermediate wheel c, and its axle 0·04 metres diameter:

$$S'_6 4 = \frac{S'}{2}u_2\frac{0{\cdot}02}{0{\cdot}10} = \frac{2}{5}S'u_2.$$

7. Friction the shaft B and bearing β, caused by transmitting the pressure P_2, the pressure between the journals 0·06 metres diameter, and the bearing β_1 amounts to $0{\cdot}72\,P_2 \times 2 = 0{\cdot}36\,S'$, so that

$$S'_7 = 0{\cdot}36\,S'\frac{0{\cdot}03}{0{\cdot}10}u_2 \times 4 = 0{\cdot}432\,S'u_2.$$

8. Friction between journal 0·05 metres diameter of shaft B_1 and bearing β_2 due to the same cause:

$$S'_8 = 0{\cdot}28\frac{S'}{4} \times 2\,\frac{0{\cdot}025}{0{\cdot}100}u_2 \times 4 = 0{\cdot}14\,S'u_2.$$

9. Friction between the bearing β_1 and the shaft B caused by the pressure of the springs. That part of this pressure to be resisted by the bearing β_1 amounts to $\frac{1}{5}S'$, so that

$$S'_9 = \frac{1}{5}S'u_2 \times \frac{0{\cdot}03}{0{\cdot}10} = \frac{3}{50}S'u_2.$$

10. Friction between bearings β_2 and shaft B_2, arising from the pressure of the springs:

$$S'_{10} = \frac{1}{5}S'u_2 \times \frac{0{\cdot}025}{0{\cdot}100} = \frac{1}{5}S'u_2.$$

11. Friction between the long sleeve of the drum e and the shaft B, and arising from the pressure P_3 and the pressure of the springs:

$$S'_{11} = S'u_2 \times \frac{0{\cdot}025}{0{\cdot}100} - \frac{1}{5}S'u_2 \times \frac{0{\cdot}025}{0{\cdot}100} = \frac{S'}{8}u_2.$$

This resistance is positive if B is the driven, and negative if A is the driven shaft. The effective pressure S of the pair of springs is as follows if A is the driven shaft:

$$\begin{aligned} S &= S'_1 + S'_2 + S'_3 + S'_4 + S'_5 + S'_6 + S'_7 + S'_8 + S'_9 + S'_{10} - S'_{11} \\ &= \Big\{ 1 + u_1\left(\frac{1}{36}+\frac{1}{12}\right)\pi + u_2\left(\frac{3}{50}+\frac{2}{5} + 0{\cdot}432 + 0{\cdot}14 + \frac{3}{50}+\frac{1}{5}\right. \\ &\qquad \left.-\frac{1}{8}\right)\Big\} = S'\,(1 + 0{\cdot}350\,u_1 + 1{\cdot}167\,u_2). \end{aligned}$$

The coefficient of friction for the teeth of the wheels may be taken after Morin as

$$u_1 = 0{\cdot}150,$$

and that for the journals and bearings as

$$u_2 = 0{\cdot}054,$$

so that by substituting their values we obtain

$$S = S'\,(1 + 0{\cdot}35 \times 0{\cdot}15 + 1{\cdot}167 \times 0{\cdot}054) = 1{\cdot}116\,S'.$$

Consequently the pressure of the springs to be substituted in the equation to find E is:

$$S' = \frac{1}{1 \cdot 116} S = 0 \cdot 896 \, S.$$

If B be the driven shaft, we shall have

$$S = S' + S'_1 + S'_2 + S'_3 + S'_4 + S'_5 + S'_6 + S'_7 + S'_8 + S'_9 + S'_{10} + S'_{11} = S = 1 \cdot 112 \, S'.$$

So that in this case the pressure to be substituted for E is:

$$S' = \frac{1}{1 \cdot 112} S = 0 \cdot 899 \, S.$$

As both approximate, the mean may be taken $= 0 \cdot 897$ S.

Finally,

$$E = \frac{0 \cdot 897}{2} \times S \frac{\pi r u}{60} 0 \cdot 002348 \, S \, u \text{ kilogramme metres per second.}$$

It is advisable to ascertain the exact value of E by trial, which may be done as follows. One end of a strong silk string, long enough to be rolled several times round the pulley, is fixed to the circumference of one fast pulley, while a second similar string is fastened to the circumference of the other. The end of one string is loaded, whilst by the other the load is slowly lifted, and the recording apparatus being connected, diagrams are obtained, due to absolutely known work performed in lifting the weights. By this means the data can be obtained for calculating a scale which measures, on the diagram, the resistances overcome.

LONDON:
Printed by GEORGE E. EYRE and WILLIAM SPOTTISWOODE,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.

Digitized with financial assistance from the
Government of Maharashtra
on 02 July, 2018